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COMPUTER BASED ECONOMIC ANALYSIS TECHNIQUES
TO SUPPORT FUNCTIONAL ECONOMIC ANALYSIS

by

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September 1993

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Submitted in partial fulfillment

of the requirements for the degree of
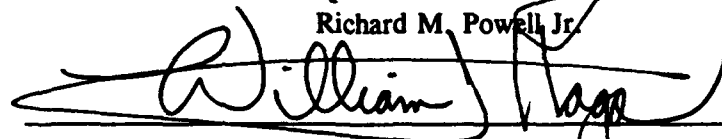
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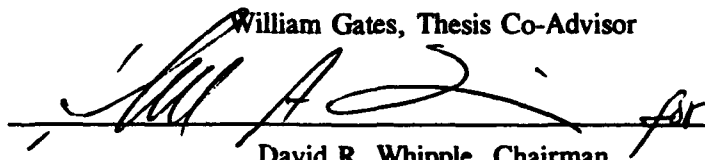
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ABSTRACT

The purpose of this thesis is to present different economic analysis techniques available for evaluating costs and benefits associated with the procurement of Information Systems. The thesis will address each of these techniques in detail and develop a problem set supporting this discussion. The standard set will be used to perform a functional test of PC Econpack, a decision support system (DSS) currently fielded by the Army Corps of Engineers. DSS output will be evaluated to determine the accuracy and examine the portability of this software application to support functional economic analysis methodology as contained in DoD Directive 8000.1. Results will be analyzed to determine conditions of mutual support, conflict and consistency.

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I. INTRODUCTION

A. INTRODUCTION

Garrison (1991) states that management science has developed numerous techniques which support resource allocation for capital investments. From these techniques Haga and Lang (1992) refined seven management tools which support Functional Economic Analysis. These management techniques relate to specific characteristics corresponding to capital investments in information technology (IT).

Walker (1991) wrote that IT related investments have grown dramatically in the DoD over the last 10 years. This view is generally accepted within the IT community and is expected to continue. Straussman (1985) wrote that 33.4% of the U.S. private sector capital investments were for computer equipment. He projected that this trend would continue through the 1990's and eventually 70% of total U.S. GNP would be consumed for these purposes. To keep pace with this trend and promote prudent resource allocation, Parker and Bensen (1988) theorize that business performance and information technology must be linked. Only through this union can the benefits and values that these investments bring to the organization be considered.

B. WHAT IS IT WORTH?

By their very nature, capital investments are future oriented. Quirin and Winginton (1981) describe capital investments, particularly in technology, as strategic decisions which are expected to return future benefit. Parker and Benson (1988) point out that value is based on improved business performance and cost is based on total organization outlay. These two factors considered together define the true economic impact of IT: the value the investment brings to the business less the cost of this investment.

C. FUNCTIONAL ECONOMIC ANALYSIS

In response to changes in U.S. security interests, the military threat assessment, and reduction in the DoD, process reviews were initiated to identify cost savings wherever possible. Part of this review called for a methodology to determine costs and benefits. Particular scrutiny was directed to IT capital investments and business improvements. This process, established in DoD directive 8000.1, is called Functional Economic Analysis (FEA). Straussman (1992) wrote in the forward of the FEA guidebook,

> FEA is an evolving methodology ... that will change as new techniques and tools are developed ... in applying the methodology.

The FEA guidebook says the goal of FEA is to support functional process improvement which identifies, evaluates, and implements improvements with the DoD. These steps are

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undertaken to facilitate cost-effective improvements to help DoD meet budget reduction targets established by Defense Management Review (DMR)

D. OBJECTIVE AND SCOPE

The objective of this thesis is to examine capital investment decisions using the Functional Economic Analysis tools. These tools should support the decision making process and help quantify values and costs associated with IT investments.

Costs will be reviewed by describing seven analysis techniques contained in the Haga and Lang text. Criteria will be examined for selecting the appropriate analysis tool to evaluate IT investments. A problem set will be developed for each analysis technique. Each of these problems will be solved manually and presented within the text.

II. THE TIME VALUE OF MONEY

A. BACKGROUND

By its very nature, financial decision making involves behavior which implies the existence of a goal or set of goals. At the heart of this decision making process is the time value of money. From the standpoint of capital investment, a dollar received tomorrow is not equivalent to a dollar today. As a result, capital investment decisions compare present outlays against future benefits.

An intelligent investment decision requires comparing economic alternatives. These alternatives must account for the fact that money can earn a positive return. This principle makes time important in capital investment decisions.

Interest is fundamental in evaluating capital investments. It can be considered from two view points. If interest is paid, it is considered a cost. Conversely, if interest is received it is considered a return. Since money can earn a return over time, interest rates express the time value of money. There are two terms used almost synonymously when discussing the future value of money: interest and interest

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rate. Interest is expressed in dollars and represents the money paid or received over time. The interest rate is a percentage which expresses the fraction of cost or return on the principal over time.

B. SIMPLE INTEREST

When interest is paid only on the principal, it is referred to as simple interest. Simple interest is computed by the following expression.

$$I = P * n * i \qquad \text{Equation 2-1}$$

Where P=Principal, n=number of interest periods, and i=interest rate.

The simple annual interest on $100 principal at 10% interest for one period is calculated in Example 2-1.

$$\$100 * 1 * 0.1 = \$10 \qquad \text{Example 2-1}$$

The future benefit of interest is the sum of principal plus simple interest accumulated over a period of time.

$$FV = P + I$$

$$FV = P + (P * n * i)$$

$$FV = P(1 + n * i) \qquad \text{Equation 2-2}$$

C. COMPOUND INTEREST

Simple interest explains the concept of present value, and the function of interest over time. Simple interest is not used with relative frequency in business decisions. Compound interest is commonly used to calculate interest upon the unpaid balance of principal over time. This is accomplished by adding unpaid interest to principal at the end of a period, before calculating the total interest due upon this balance. To account for this future value the compound interest formula is used.

$$FV=P(1+i)^n \qquad \text{Equation 2-3}$$

This formula states that the future value of money is equal to the principal multiplied by the sum of one plus the interest rate raised to the number of periods (n years). For example, the future value of $100.00 invested at 10% for two years is calculated as:

$$FV=\$100(1+.1)^2=\$121 \qquad \text{Example 2-2}$$

To further demonstrate the principle of compound interest consider what occurs when $10,000 is borrowed at 15% interest and no principal is paid during the first year. $11,500 is due at the end of the first year using simple interest

(Computed as $10,000 principal plus $1,500 interest.) If this balance of $11,500 is carried for a second year an additional 15% interest would be due on the total unpaid balance from year one (principal + interest).

This would result in the following equation:

$$FV=P*(1+i)+[i(P*(1+i))] \qquad \text{Equation 2-4}$$

this would be simplified algebraically to:

$$=P*(1+i)*(1+i) \text{ or}$$

$$FV=P*(1+i)^2$$

In the example $10,000 at 15% interest over a 2 year period would be worth:

$$FV=P*(1+i)^2$$

$$FV=\$10,000*(1+.15)^2$$

$$\$13,225.00$$

This compound interest formula can be used for longer periods of time. The previous formula is modified so that the exponent (n) in Equation 2-3 is equal to the number of years that interest is to be accumulated.

Example: Suppose that $1,500 is borrowed for 5 years at 10% interest. What will be the amount due if no payment is made until the end of the fifth year?

$$FV=P(1+i)^n=$$

$$\$1,500*(1+0.1)^5=$$

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$$\$1,500 * (1.61051) =$$

$$\$2,416$$

D. PRESENT VALUE

From the calculation of the Future Value of money, we can determine the present value formula. This derivation of the compound interest formula will adjust a sum of capital at a future time and adjust it to present value. The present value (PV) formula is :

$$PV = \frac{FV_n}{(1+K)^n}$$ Equation 2-4

This formula can be read as the present value (PV) of future value dollars at the end of (n) years when the interest rate is K. This is used to discount future values to the present. This tool can be extremely useful in making capital investment decisions, because time affects the value of money.

The concept of interest is used to show the future value of money over time in relation to an expected rate of return. However, this concept of future value is predicated upon the possibility of uncertainty. While loaning money at 10% may seem a safe proposition, it could prove disastrous if inflation was 15% over that period of time. Considering both the time value of money and uncertainty, it is generally accepted that possessing money today is better than money in the future. If presented with the alternative of receiving

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money now or the same amount of money two years from now, economically it is more advantageous to receive the money now. Stevens (1979) calls this the "bird in the hand" principle. This principal addresses both the time value of money and the degree of uncertainty associated with the transaction. By receiving the funds now the capital can be invested to provide a higher sum of money in the future.

The Federal Government has outlined procedures for evaluating capital investments in Office Management Budget (OMB) Circular A-94 and DoD Instruction 7041.3. These regulations are employed in evaluating time distributed costs and benefits. The recent revision to OMB circular A-94, dated 29 Oct 1992 specifies that a discount rate from 4% to 7% should be used to evaluate capital investments. The former version of this directive called for a discount rate of 10%. To illustrate the effects of this change both 7% and 10% discount rates are provided in Appendix A. All example problems are solved using a 7% discount rate in Appendix C.

There are three discounting conventions that are used to measure dicounting factors, they are: Beginning of the Year (BOY), Middle of the Year (MOY) and End of the Year (EOY). Consider a $100 payment. If the interest payment is made on the first day of the year, we receive the payment one year earlier than the interest occurs. This discount strategy is an example of the BOY discounting convention. The BOY discounting formula is displayed in Equation 2-5(a).

$$BOY = \frac{1}{(1+i)^{(n-1)}}$$ Equation 2-5(a)

If the interest payment were received at the end of the year, the interest due would be accumulated for the entire year. This represents the EOY discounting convention. The formula for EOY is shown in Equation 2-5(b).

$$EOY = \frac{1}{(1+i)^{n}}$$ Equation 2-5(b)

The current OMB circular states that "when costs and returns occur in a steady stream" applying a mid-year discount factor may be more appropriate. Within the Department of Defense, funds appropriated by Congress are apportioned in a "steady stream" and expenditures for capital investment are realized as services or goods are received. Therefore, the middle of the year convention is used by agencies within DoD.

According to the OMB circular, the discount tables presented in Appendix A & B are adjusted to the mid year convention by computing the discount factor by using Equation 2-5(c).

$$MOY = \frac{1}{(1+i)^{(n-0.5)}}$$ Equation 2-5(c)

For example the present value cost for $1 in year one at 10% used mid-year conversion is:

$$MOY = \frac{1}{(1+.1)^{(1-0.5)}} = 0.954 \qquad \text{Example 2-3}$$

The mid year convention is used instead of the beginning of the year or end of the year factors because:

- After the initial investment cost, most annual costs and benefits associated with a project do not occur at a single time. These costs occur uniformly throughout the year, and for capital budgeting purposes the annual lump sum payment or mid-year conversion will approximate these costs.

- The exact time and occurrence of costs and benefits may involve a certain degree of uncertainty. In the absence of perfect information, costs could occur randomly throughout the year, and therefore average factors would apply for explaining these occurrences. Additionally because these values would involve random occurrence the mean or average would discount resulting errors.

The appropriate mid-year conversion discount factors to be used within DoD are included in Appendix A. The remainder of this paper assumes a 10% discount factor.

III. NET PRESENT VALUE TECHNIQUE

A. BACKGROUND

The Present Value method evaluates the desirability of a capital investment and considers the time value of money. The benefit of this investment can be considered two ways. The merit of an investment decision may be evaluated based on the present utility, or on it's future benefit. In either case three underlying conditions must apply to each alternative.

1. Equal economic lives.

2. Equal non-monetary benefits from each alternative.

3. The economic lives must be determined.

B. CALCULATION OF NET PRESENT VALUE

Once each of these conditions are met, the net present value technique is appropriate for comparing alternatives. In performing this analysis, all costs and revenues associated with an alternative are accumulated and are programmed over time. This analysis uses the current year as the date to compare alternatives. The preferred option has the highest present value. Alternatively, if the investment does not directly generate revenues, as with most information

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technology investments, the investments costs over time are discounted to their present value. In this case, the preferred option has the lowest present value and is often called the least cost alternative. This discussion will consider this later class of investments.

The analysis is accomplished by estimating total cost, both recurring and nonrecurring, for each year over the project's economic life. Each annual total cost is then multiplied by the discount factor for that year, as contained in Appendix A. The product of the total annual cost times the discount factor equals the annual discount cost. The product of each annual discounted cost is then summed to determine the present value.

The Figure 3-1 is a common discount table format.

```
Year               0        1        2         3        n
Outlay            (A)      (B)      (C)       (D)      (x)
PV Factor         1.0      .954     .867      .788     (y)
Present Value    (A*1.0)  (B*.954) (C*.867)  (D*.788) (x*y)

Total Cost                 SUM OF EACH YEAR'S PRESENT VALUE
```

Figure 3-1 Common Discount Table Format

To examine the present value technique, several illustrations will be considered. For the first analysis, assume that the current information system is unacceptable and must be replaced. Management is considering two competing

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systems. The economic life of each system is five years. The first alternative has an optional maintenance contract. The terms of the maintenance agreement spread the cost over each of the out-years, but reduces the initial outlay. Alternative two is a similar system that offers a maintenance agreement which is included in the purchase price. Annual fees are included in both contracts over the out-years to provide for software updates and periodic hardware maintenance. In each of the alternatives, the majority of the planned expenditures will occur at the beginning of the system's economic life. As a result of the up front cost distribution, both of the options are termed "front loaded" capital investments. A summary of each alternative is provided in Figures 3-2, 3-3, and 3-4.

Cost Factors	Alternative 1	Alternative 2
Economic Life	5 years	5 years
Procurement Cost	$20,000	$25,000
Maintenance cost	$3,000 per year	$1,000 per year

Figure 3-2 Summary of Example 1 Alternatives

To decide which of these two alternatives is preferable, management will discount the cost of each alternative to its present value. For this and all subsequent analysis we will use a 10% interest rate.

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The present value technique involves discounting the annual costs of each competing option to the present value. The alternative with the lowest discounted cost is preferred.

Figure 3-3 provides the economic analysis for the first alternative.

```
Alternative 1:
Year            0        1        2        3        4        5
Outlay     $20,000  $3,000   $3,000   $3,000   $3,000   $3,000
PV Factor     1.0     .954     .867     .788     .717     .652
PV         $20,000  $2,862   $2,601   $2,364   $2,151   $1,956

Total Cost                                              $31,934
```

Figure 3-3 Net Present Value Alternative 1

The initial cost of purchasing the first system is $20,000. This payment is made at the beginning of the current year. Maintenance costs are paid annually over the assets anticipated useful life. The actual out year maintenance costs are adjusted to consider them in present value. A standard 10% discount factor is applied and the corresponding discount factor is included in the present value column of Figure 3-3. Each year's outlay is then multiplied by its corresponding present value factor and the product is the adjusted present value. The adjusted present values for each

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year are summed to arrive at the total present value of $31,934 for alternative one.

```
┌─────────────────────────────────────────────────────────────┐
│                                                             │
│   Alternative 2:                                            │
│                                                             │
│   Year          0        1        2        3        4        5 │
│   Outlay    $25,000  $1,000   $1,000   $1,000   $1,000   $1,000 │
│   PV Factor    1.0     .954     .867     .788     .717     .652 │
│   PV        $25,000   $954     $867     $788     $717     $652 │
│   Total Cost                                           $28,978 │
│                                                             │
│                                                             │
└─────────────────────────────────────────────────────────────┘
```

Figure 3-4   Net Present Value Alternative 2

The calculations for Alternative 2 are determined as previously described and Figure 3-4 provides the economic analysis for the second alternative. Alternative 2 has a total present value cost of $28,978. Management would then compare the present value costs of each alternative. If the decision for acquisition was made solely on cost data, then Alternative 2 with its lower cost would be preferred.

Often competing alternatives are not front loaded. An example would be when a firm considers leasing instead of buying. In this example each system will be leased and purchased at the end of their lease. This illustration demonstrates how the present value is affected when the bulk of the expenditures are at the end of the economic life.

The lease options (Alternatives 3 and 4) assume that the initial payments of the alternatives are not due until the final periods of their economic lives. In each case, there is an up front payment equal to one fifth of the system cost plus

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the annual maintenance cost. The annual maintenance expenditure for years 2 through 4 are equally distributed, as before. The bulk of the costs are incurred in year five with the lease payoff or residual. Figure 3-5 represents the present value calculations for the lease options.

Alternative 3:						
Year	0	1	2	3	4	5
Outlay	$7,000	$3,000	$3,000	$3,000	$3,000	$20,000
PV Factor	1.0	.954	.867	.788	.717	.652
PV	$7,000	$2,862	$2,601	$2,364	$2,151	$13,040
Total Cost						$30,018

Alternative 4:						
Year	0	1	2	3	4	5
Outlay	$6,000	$1,000	$1,000	$1,000	$1,000	$25,000
PV Factor	1.0	.954	.867	.788	.717	.652
PV	$6,000	$954	$867	$788	$717	$16,300
Total Cost						$25,626

Figure 3-5 Net Present Values for Lease Options

Based on economic analysis Alternative 4 is the least cost option and would be preferred.

A comparison between the front (Alternatives 1 and 2) and rear load (Alternatives 3 and 4) options demonstrates the cost impact of the different funding strategies. The leasing alternatives have lower total present value costs than the buying options. This results from shifting the preponderance of the commitments to the end of the economic lives. Of course, the benefit of back loading an investment decreases

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with the discount rate. The front loaded option may be more attractive if the discount rate is low enough. For example, alternative 2 would become the least cost alternative if the discount rate is less than 5.33%, a value with in OMB's guidelines.

A naive comparison of Alternative 1 and Alternative 4 would convey that over the 5 year period $35,000 of un-discounted capital would be invested on each proposal. This unadjusted investment would not account for the time value of money related to front or rear-loaded funding profiles. By recognizing that capital value is adversely influenced by time the Net Present Value method reveals that the present value of Alternative 1 is $6300 more than Alternative 4 over the system's economic life.

Using the net present value technique a more thorough analysis of the alternatives is possible. By assigning relative weights to the cash flow determines the true cost of proposals over their economic life.

Back-loading, or shifting the preponderence of expenses to the end of an alternatives economic life will lower present value cost at sufficiently high discount rates. Back-loaded investments are generally more sensitive to discounting, because the Present Value factor decreases over time.

In Alternative 4, the least cost option, 71% of its total capital investment is incurred during the last year of the systems economic life. If $16,300 is invested today at 10%

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interest, it will grow to the required $25,000 by the fifth year. If the activity has alternative investment that earn at least a 10% rate of return, it would be profitable to back-load this project and use its current funds in the alternative investment.

The previous examples demonstrate how the net present value analysis can be used to determine a project's desirability. It accounts for the flow of capital with respect to time and looks at capital distribution over economic life. A strength of this technique is that it can determine the preferred option from alternatives having different cash flow distribution. A limitation of this technique is that costs or benefits must be expressed in dollar values. It has no mechanism to analyze non-monetary benefits associated with alternatives.

C. SUMMARY

The net present value technique is an effective decision making tool to evaluate monetary cash flow and distribution. It accounts for the time value of money and converts expenses over useful life to present financial cost. This technique should be used in conjunction with other analysis methods which examine potential non-monetary benefits to provide a complete project analysis.

IV. UNIFORM ANNUAL COST

A. BACKGROUND

The Net Present Value technique is an acceptable analysis method if both alternatives have equal economic lives. However, this pre-condition doesn't exist for all capital investments. According to Stevens (1979), the most inclusive approach to comparing costs for projects with unequal lives is to generate the annual adjusted cost of each alternative.

The Uniform Annual Cost (UAC) technique takes alternatives with different service lives and puts them on a level playing field. UAC calculates each alternative's life cycle cost as an annual average expenditure. This is accomplished by computing the cumulative present value for each alternative and then dividing by a cummulative discount factor that corresponds to the investments economic life. The alternative with the lowest annual cost would be economically the most desirable.

Haga and Lang (1992) assert that the following assumptions should be applied when using the Uniform Annual Cost method:

1. All alternatives evaluated must posses the same requirements specifications.

2. The economic life is the limiting factor associated with each alternative. The basic requirements extend beyond the economic life and technology plays ro significant role in the consideration.

3. Each alternative is assumed to provide the same or equivalent benefit each year. This assumption maintains that the same productivity potential exists over the expected economic life.

4. Only uniform recurring costs are considered.

5. Each alternative's cash flow pattern will continue indefinitely.

6. The annual cost of one alternative exceeds that of the other alternative.

B. CALCULATION OF UNIFORM ANNUAL COST

The UAC is calculated by determining the present value cost of each alternative. The present value is calculated as detailed in the previous chapter. The present value is then divided by the cumulative discount factor corresponding to the alternative's economic life. Appendix A provides the cumulative discount factor for different interest rates and service lifes. The mathematic formula for the UAC can be expressed as:

$$UAC = \frac{PV}{B_n} \qquad \text{Equation 4-1}$$

Where PV represents total present value and Bn equals the cumulative uniform discount factor for the year "n" (n= service life in years).

Because the formula uses the cumulative uniform discount factor in the denominator (B_n) it acknowledges the time value of money. Dividing by the economic life would result in a "mean cost" and provide misleading information upon which to base an economic decision. For example, say that you were

evaluating a small network which would have a five year service life and had a procurement cost of $30,000.00. By using UAC you would determine that the network would cost you $7,543.38 annually.

$$UAC = \frac{PV}{B_n} = \frac{\$30,000}{3.9804} = \$7,534 \qquad \text{Example 4-1}$$

The annual mean approach is inappropriate because it does not express the time value of money. This is important for cash flows over time. The UAC calculations indicates that if you put $30,000 in the bank this year and earn a 10% interest rate, you could withdrawal approximately $7,500 per year for each of the next 5 years. After the fifth withdrawal, the account balance would be zero.

	ALTERNATIVE A	ALTERNATIVE B
INITIAL COST	$325,000	$350,000
ANNUAL COST		
1	$35,000	$25,000
2	$35,000	$25,000
3	$35,000	$25,000
4	$45,000	$25,000
5	$40,000	$50,000
6	$35,000	
7	$35,000	
8	$60,000	
SERVICE LIFE	8 YEARS	5 YEARS

FIGURE 4-1 Uniform Annual Cost Alternatives A & B

To see how UAC ranks alternatives with different economic lives, consider the following example. As the Information Systems Manager for an activity, you have been tasked with installing a new command-wide network. You have narrowed the possibilities to two equally effective alternatives and are considering the information contained in Figure 4-1. You want to determine which would be the most economical over its service life.

The first step in calculating the UAC would be to compute the NPV for each alternative.

Comparing the initial values form Alternatives A and B it would appear that Alternative B is the most favorable. Alternative B has a total present value of $465,750.00. However, it also has an economic life of 5 years. Because the

```
ALTERNATIVE A

YEAR     0      1      2      3      4      5      6      7      8

        $325k  $35k   $35k   $35k   $45k   $40k   $35k   $35k   $60k
DISCOUNT
FACTOR   1     .954   .867   .788   .717   .652   .592   .538   .489

        $325k  $33k   $30k   $28k   $32k   $26k   $21k   $18k   $29k

                                         TOTAL NPV₄ = $542,855

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

ALTERNATIVE B

YEAR     0      1      2      3      4      5

        $350k  $25k   $25k   $25k   $25k   $50k
DISCOUNT
FACTOR   1     .954   .867   .788   .717   .652

        $350k  $24k   $22k   $20k   $18k   $33k

                            TOTAL NPV₆ = $465,750
```

FIGURE 4-2   Comparison of Each alternative's NPV

two alternatives have differing economic lives we will use the UAC method.   Calculating each alternative's UAC is shown in Examples 4-2(a) and 4-2(b).

$$UAC_a = \frac{PV_a}{B_8} = \frac{\$542,855}{5.597} = \$96,990 \quad \text{Example 4-2(a)}$$

$$UAC_b = \frac{PV_b}{B_5} = \frac{\$465,750}{3.978} = \$117,111 \quad \text{Example 4-2(b)}$$

In this example, Alternative A is the preferred solution. By using the UAC method we compensate for different service lives and account for the time value of money.

The UAC method compares total costs per year of production. When using UAC, care should be taken to spread the cash flows only over the actual economic life of the alternative. Garrison (1991) says costs associated with plant property or facilities acquisition should also be spread over the alternative's economic life. These are lead time costs. Lead time costs are illustrated in the following example.

You must provide a military digital data link for satellite communications near the California Central Coast. With the closure of Ft. Ord, a facility exists and offers an immediate benefit. It has an initial investment cost of $2.2 million and an operating cost of $220k per year for 8 years. After 8 years, a modernization program for the facility would be considered to accommodate capacity. Modernization cost is estimated to be $1.4 million. An alternative is to build a $4.2 million facility at Camp Roberts, California. It would take 3 years to complete the facility, and would then have an operating cost of $220 per year for 30 years. The residual value for the facility would be $1.5 million. Determine the UAC for each alternative.

Solution to Alternative A:

$$PV_a = \$2.2m + \$220k*(5.108) + \$1.4m*(.489) = \$4,008,360$$

$$UAC_a = \frac{PV_a}{B_8} = \frac{\$4,008,360}{5.601} = \$716,162$$

Alternative B

$$PV_b = \$1.4m * (2.821) + 220k * (8.173) - \$1,5m * (.049) = \$5,673,960$$

$$UAC_b = \frac{PV_b}{B_{32}} = \frac{\$5,673,960}{9.994} = \$567,736$$

C. SUMMARY

The uniform annual cost method of cost analysis provides users with a useful tool for evaluating capital investment alternatives with different economic lives. This method looks at a series of capital outlays corresponding to production years and evaluates production based on a constant amount for each year. This method involves dividing the present value of the alternative by it's cumulative discount factor over the economic life.

Because the UAC method is based on the present value analysis, it incorporates the time value of money into the final results. This analysis tool can be extremely useful to support the decision making process.

V. SAVINGS INVESTMENT RATIO

A. BACKGROUND

The Savings Investment Ratio (SIR) is a method of economic analysis used to rank capital budget proposals based on their potential for cost savings. The SIR manipulates data so projects with different economic lives and different cash flows can be examined and compared.

B. CALCULATING SAVINGS INVESTMENT RATIO

Zimmerman (1980) defines the SIR as the result of future costs savings and the investment necessary to generate this savings. When computing SIRs, the focus is not on total operating costs or annual outlay, instead it considers the cost over total life cycle of the investment. SIR evaluates the potential difference between the total life cycle costs and the effect this investment may have on operations.

Haga and Lang (1992) defined the Savings/Investment Ratio as:

$$SIR=\frac{PV_s}{PV_i}$$

Equation 5-1

(Where PV_s is the present value of savings, and PV_i is the present value of initial investment.)

The relationship between savings and investment is important to determine economic feasibility of a proposal. If the ratio of the present value of savings compared to the present value of investment are equal, then the SIR will equal one. For any alternative to be considered economically feasible, a SIR rating less than one should not be contemplated.

The value of all financial considerations (investments, savings and salvage value) over the life of the investment are considered. To incorporate the time value of money and sensitivity for the timing of cash flows, the present value of these variables are applied consistently.

Example: Suppose you are working for a national magazine that has conducted a vulnerability assessment of the corporate network. The proposal evaluates an information system supporting 2,200 computer work stations. The assessment has determined that the network is highly vulnerable. It estimates the magazine will loose $500,000 in direct sales this year and a total of $500,000 in market share over the next ten years if the security deficiency is not corrected. Costs for the secure system is $320 per computer with a $20K salvage value at the end of it service life. The Computer Information Officer (CIO) desires a economic analysis to evaluate this proposal.

Solution: Figure 5-1 depicts the difference between savings and investment.

```
Savings     500  50    50    50    50    50    50    50    50    50    50
            ├────┼─────┼─────┼─────┼─────┼─────┼─────┼─────┼─────┼─────┤
Year        0    1     2     3     4     5     6     7     8     9    10
            ├────┼─────┼─────┼─────┼─────┼─────┼─────┼─────┼─────┼─────┤
Investment 704                                                        20
```
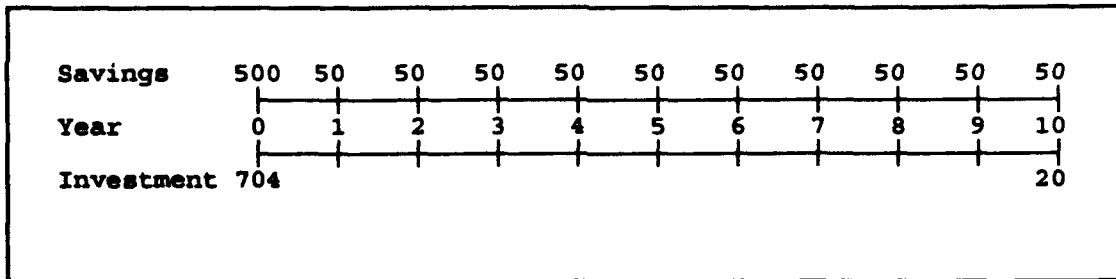
Figure 5-1   Example 1 Cash Flow.

Tc calculate the SIR you compute the ratio of the savings to the present value of investment less the present value of the terminal value:

$$SIR = \frac{PV_s}{PV_i} =$$

$$\frac{500k + 50k*(6.446)}{704k - 20k*(.405)} =$$

$$SIR = \frac{822k}{696k} = 1.18 \qquad\qquad Example\ 5\text{-}1$$

Since the SIR is greater than one, the investment is economically sound. The present value of the security system savings exceeds the present value of its cost.

C. COMPARING INVESTMENT PROJECTS

Because the SIR quantifies the relationship between savings and investment over the lifetime of a project, options with high numerical ratios are more economically desirable than those with lower ratios. SIR values can be used to

prioritized capital budget projects. Under this concept, those projects would be funded in descending order until financial resources were exhausted. This methodology is useful to establish priorities when decisions are economically based.

You are preparing a $2.4 million budget for multi-year programs. These programs will update current equipment and reduce your company's operating costs. Through methodical analysis all but the following five proposals have been eliminated. These are shown in Figure 5-2. SIR can help determine which should be funded.

PROJECT	INITIAL INVESTMENT	NET OPERATING COST SAVINGS	ECONOMIC LIFE
(1) OPTICAL SCANNER	$600K	$100K	12 YEARS
(2) SECURITY H/W,S/W	$704	$120K	10 YEARS
(3) INVENTORY SYSTEM	$1,200K	$250K	8 YEARS
(4) ADP MODERNIZATION	$550K	$150K	5 YEARS
(5) NETWORK UPGRADE	$600K	$120K	8 YEARS

Figure 5-2 Competing Proposals for Example 5-2

Through SIR analysis it was determined that all five projects were economically efficient because the ratio of present value of savings to present value of investment exceeded the ratio of 1. However, each of these projects are competing for limited resources and full funding. Funding

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every project is not possible. Therefore, only the most economically efficient programs will be considered. SIR calculations are provided in Figure 5-3 to determine the funding priority.

PROJECT	SIR	FUNDING PRIORITY
OPTICAL SANNER	($100K*7.148)+ $600K = 1.19	1
SECURITY H/W,S/W	($120K*6.446)+$704K = 1.10	4
INVENTORY SYSTEM	($250K*5.597)+$1,200K = 1.17	2
ADP MODERNIZATION	($150K*3.978)+$550K = 1.08	5
NETWORK UPGRADE	($120K*5.597)+$600K = 1.12	3

Figure 5-6 SIR Calculations for Funding Priority

This example demonstrates that SIR is a valuable decision making tool. Competing alternatives can be ranked on a common basis regardless of service life or cash flow. Because the evaluation is performed using the present value assumption, each ratio is sensitive to the time value of money. Finally because each analysis is expressed as a ratio, a higher result is preferable. The ratio expression permits these proposals to be prioritized for funding.

The SIR technique can be used to evaluate and prioritized competing projects. It can also be used to evaluate different

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cash flows within the same project. The SIR technique will reveal which alternative returns the greatest savings per dollar of initial investment. Because this methodology is sensitive to the time value of money, the preferred alternative will have the lowest present value cost. The following example will show how to compare alternative cash flow strategies for the same proposal.

It was previously determined that optical scanning equipment had the highest SIR. Management decided to fund this project. When the Purchasing and Contracting Department contacted the vendor, they discovered that the business could lease or buy the equipment. They obtained information regarding the lease.

The lease assumes a manufacturer's suggested retail price of $625,100 with a capitalized cost reduction of $25,100 plus a down payment of $40,000. The down payment plus first month's payment are due at the lease inception. Annual lease payment is $92,160 for 5 years. At the end of the lease, the Optical Scanning Equipment may be purchased at the fair market value, estimated at $295,000. All other assumptions remain valid.

The cash flow diagram for the lease and buy options are shown in Figure 5-4:

Solution: To compute the SIR for each lease option the SIR formula is expanded to accept the cash flow over each year.

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```
Alternative A (Buy Option):

Savings          100 100 100 100 100 100 100 100 100 100 100 100
         ├───┼───┼───┼───┼───┼───┼───┼───┼───┼───┼───┼───┤
Year     0   1   2   3   4   5   6   7   8   9   10  11  12

Invest   600                                              20


Alternative B (Lease Option):
Savings        100 100 100 100 100 100 100 100 100 100 100 100
         ├───┼───┼───┼───┼───┼───┼───┼───┼───┼───┼───┼───┤
Year     0   1   2   3   4   5   6   7   8   9   10  11  12

Invest   132  92  92  92  92  92  295
```
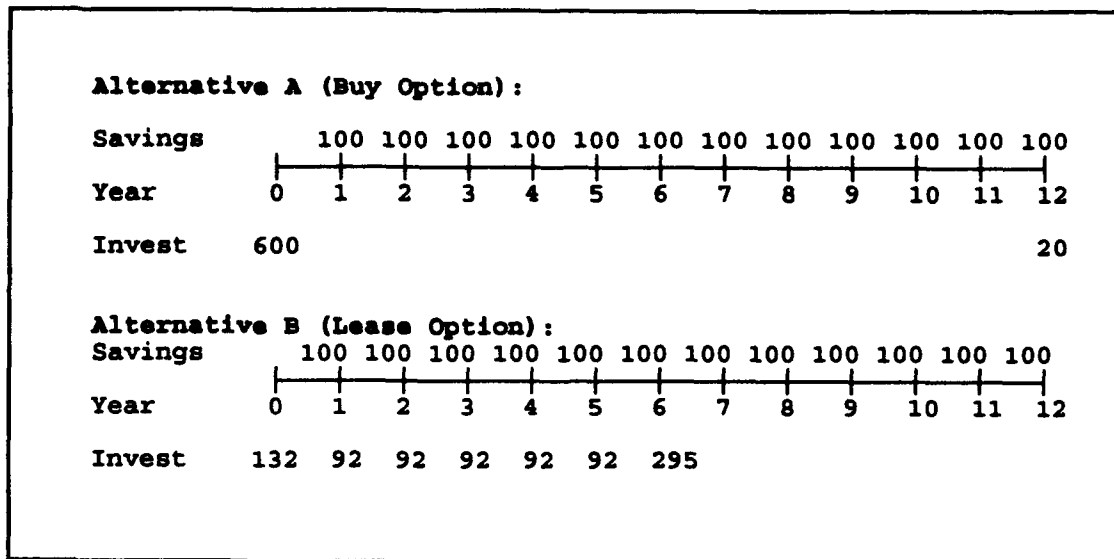
Figure 5-4   Cash Flow Diagram for Example 5-2.

$$SIR = \frac{\sum PV_s}{\sum PV_i} \qquad \text{Equation 5-2}$$

The purchase option remains as previously computed with a 12 year economic life.

$$SIR_{BUY} = \frac{PV_s}{PV_i} = \frac{100k(7.148)}{600k} = 1.19 \qquad \text{Example 5-3(a)}$$

$$SIR_{LEASE} = \frac{PV_s}{PV_i} = \frac{\$100k(7.148)}{\$581,160} = 1.23 \qquad \text{5-3(b)}$$

The lease option would be computed as shown in Figure 5-5.

```
Purchase = $600,000


Lease = $40,000 + (92,160 * 3.978) + (295,000 * .592) = $581,160
```

Figure 5-5   Present Value Analysis of Example 3

As a result of the analysis, the lease alternative has a higher SIR and appears to be less costly. To see if this is true, each alternative's present value could be computed, as shown in Figure 5-5. Present value analysis of the investments shows that the lease option would be the least cost alternative.

D.   SUMMARY

The Savings Investment Ratio is useful for ranking projects based on projected cost savings. It can be used to permit activities to compare and evaluate proposals with different economic life cycles and different cash flows. SIR is expressed as a ratio resulting from savings compared to its investment over the total economic life. Because the SIR uses present value methodology, it is sensitive to the time value of money. It can also be used to collaborate analysis conducted using the net present value and uniform annual cost techniques. However, like the previously discussed analysis techniques, the savings investment ratio does not consider non-monetary benefits associated with a proposal. If such

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benefits must be considered, a different analysis technique must be used.

VI. DISCOUNTED PAYBACK ANALYSIS

A. BACKGROUND

According to Garrison (1991) the discounted cash flow method of making capital budgeting decisions is relatively new. First introduced on a wide-spread basis in the mid 1950's, these discounted cash flow methods have gained widespread acceptance as accurate and reliable decision making tools.

Stevens (1979) believes that the discounted payback analysis method is probably the most widely understood discounted cash flow method. Payback analysis was designed to express data as a function of time. Walker (1991) defines the payback period as the length of time it takes for an investment to recoup its initial cost. Garrison (1991) said "in business jargon, the payback period is the time that it takes for an investment to pay for itself." The basic premise of the payback method is that the more quickly an investment recuperates initial investment, the more desirable the investment.

The more naive approach to calculating the payback period uses undiscounted cash flows. For investments with relatively constant annual cash flows, the undiscounted payable period can be calculated as shown in Equation 6-1:

$$PaybackPeriod = \frac{Investment}{NetAnnualCashInflow} \qquad \text{Eq 6-1}$$

However this naive approach has two shortcomings. First, this model does not discount the cash flows. This does not recognize time value of money during the projected payback period. Secondly, the conventional payback model does not consider costs or revenues occuring beyond the payback period. Generally projects require expenditures beyond the period necessary to recover the initial investment. Outlays like scheduled maintenance, one-time repair, overhaul, or software upgrades may be significant additional investments. Similarly, investments may generate significant cash inflows after the initial payback period. If unstated, these costs could significantly affect the proposed investment's attractiveness.

Walker (1991) accounts for these later expenses within the payback period by modifiying the naive model. The discounted payback period model addresses life-cycle costs and time value elements. According to Haga and Lang (1992), this method makes its payback when accumulated present value savings are sufficient to offset or amortize the total present value costs.

B. CALCULATING DISCOUNTED PAYBACK PERIOD

To calculate the discounted payback period divide the present value of the initial investment by the total annual savings.

$$DPA = \frac{PV_i}{S}$$ Equation 6-2

(Where PV_i is the present value of an investment and S equals the annual savings.)

The result of this equation is expressed in cumulative discount factors. Expressing this value in time is performed by mathematic interpolation, to the nearest whole years by the following steps:

1. Enter the cumulative discount factor table (found in Appendix A) with the calculated discount factor (DPA).

2. Then find the two values in the cumulative discount factor table which bracket the DPA.

3. Using these boundary values find the difference between the Upper (B_u) and Lower Boundary (B_l) values. This value is the relative bound (B).

4. Then determine the difference between the DPA and the B_l, this value is called DPA'.

5. Then divide DPA' by B which will result in the interpolated value (R). Add R to the value of B_l expressed in years.

The following example of the interpolation process is provided:

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$$Given: DPA=3.6 \; ; B_l=3.326 \; ; B_u=3.978$$

$$B=(B_u-B_l)=3.978-3.326=0.652$$

$$DPA'=DPA-B_l=(3.6-3.326)=0.274$$

$$R=\frac{DPA'}{B}=\frac{0.274}{0.651}=0.42$$

$$DPA_t= B_l \text{ expressed in time } + R=$$

$$4+0.42=4.42 years \qquad \text{Example 6-1}$$

Example: An office study indicates that if you purchase a new computer and printer to replace existing equipment your office will save $750 annually. The computer and the printer cost $2,280. The new computer suite has an expected economic life of 5 years and will have a salvage value of $250. Current office equipment has no salvage value.

Solution: First you need to check to see if the projected savings over the economic life is greater than the initial investment for the new computer.

$$PV_i-PV_t=2,280-(250*0.652)=2.117$$

$$PV_s=750*3.978=2,983$$

Since the total life cycle savings exceeds the initial investment cost, the proposal is economically acceptable. The proposal will recoup the initial investment as soon as the present values of savings and investment (less salvage values) are equal. This can be expressed mathematically as:

$$PV_s = PV_i - PV_t$$

PV_t = Present Value of Salvage

The discounted payback period is calculated:

$$DPA = \frac{PV_i - PV_t}{S} = \frac{2117}{750} = 2.823$$

2.823 falls between B_l=2.609≈3 years and B_u=3.326≈4 years.

$$B = B_u - B_l = (3.326 - 2.609) = 0.717$$

$$DPA' = DPA - B_l = (2.823 - 2.609) = 0.214$$

$$R = \frac{DPA'}{B} = \frac{0.214}{0.717} = 0.298$$

$$DPA_T = 3\,years + 0.298 = 3.3\,years$$

To demonstrate that the discounted payback method is sensitive to cash flows, consider another example shown in Figure 6-1. Upgraded computer suites would increase work station productivity and annual savings. There are two alternatives. Alternative 1 shares periphials. It has a lower initial investment but lower productivity. Alternative 2 purchases two stand alone systems.

ITEM	ALTERNATIVE 1	ALTERNATIVE 2
INITIAL INVESTMENT	$8,000	$10,000
ANNUAL OPERATING COST	$1,000	$1,000
TERMINAL VALUE	$1,000	$2,000
ECONOMIC LIFE	8 years	8 years
ANNUAL SAVINGS	$1,800	$2,400

Figure 6-1 Discounted Payback Period Alternatives

Solution: Compute   the   net   present   value   for   each
alternative.

$$PV_{alt1}=8,000+1000*(5.597)-1000*(0.489)=13,108$$

$$PV_{alt}=10,000+1,000*(5.597)-2,000(0.489)=14,619$$

According to the present value computations Alternative 1
is the least costly alternative.   Next compute the payback
period for each alternative.

$$ALT_1=\frac{PV_i-PV_e}{S}=\frac{8,000-1,000*(0.489)}{1,800}=\frac{7511}{1,800}=4.17$$

$$ALT_2=\frac{PV_T-PV_e}{S}=\frac{10,000-2,000*(0.489)}{2,400}=\frac{9,511}{2,400}=3.96$$

$$DPP_{alt1}=\frac{(4.17-3.978)}{(4.57-3.978)}=\frac{0.192}{0.592}=.324$$

DPA$_t$*=R+B*$_1$*=0.324+5 years= 5.324 years~ 5.5 years*

$$DPP_{alt2}=\frac{(3.96-3.326)}{(3.978-3.326)}=\frac{0.634}{0.652}=0.972$$

DPA$_t$*=R+B*$_1$*=0.972+4 years= 4.972 years~ 5 years*

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The Discounted Payback Analysis indicates that alternative 1 is the least cost method, but it requires a longer payback period.

C. SUMMARY

Discounted payback analysis takes the time value of money into account by discounting a project's initial investment. This analytical tool is sensitive to difficult cash flow strategies, as long as cash flows are relatively constant over time. For these reasons, discounted payback is an excellent method for comparing alternatives with different cash flows or different economic lives.

The Discounted Payback technique does have several limitations. The Discounted Payback Analysis does not identify the least cost alternative. To overcome this deficiency, each alternative should be examined with present value analysis first to determine the least cost approach. A second drawback is that the discounted payback method cannot evaluate lease versus buy alternatives or uneven investments. A lease may require little or no investment cost, which could result in a zero payback period. Uneven cash flow distribution when adjusted with present value factor could reduce the outlay such that it could be paid off before it is due. While the discounted payback method fails to consider additional savings occurring beyond the payback period, it is

a satisfactory technique to screen out alternatives with unsatisfactory payback periods.

VII. BREAK EVEN ANALYSIS

A. BACKGROUND

According to Stevens (1979), Break Even Analysis involves a study of the inter-relationship between the following factors:

1. Prices of alternative

2. Level of activity

3. Per unit variable costs.

4. Fixed Costs

5. Product mix

The analysis of the relationship between activity and profitability is a key factor in many capital investment decisions. Garrison (1990) says this relationship is so pervasive in managerial accounting that it is a consideration in virtually everything a manger does. Due to its usefulness, the Break Even Analysis is one of the most frequently used tools to uncover and explore profit potential.

B. CALCULATION OF BREAK EVEN ANALYSIS

Haga and Lang (1992) state Break Even Analysis finds the point where an alternative total revenue equals the total expense (both fixed and variable), or at a point when total contribution margin equals total fixed margin. This point is

called the "break even point." At this point the decision maker is indifferent to the investment.

Figure 7-1, adapted from Levy and Sarnat graphically represents the consideration behind break even analysis.
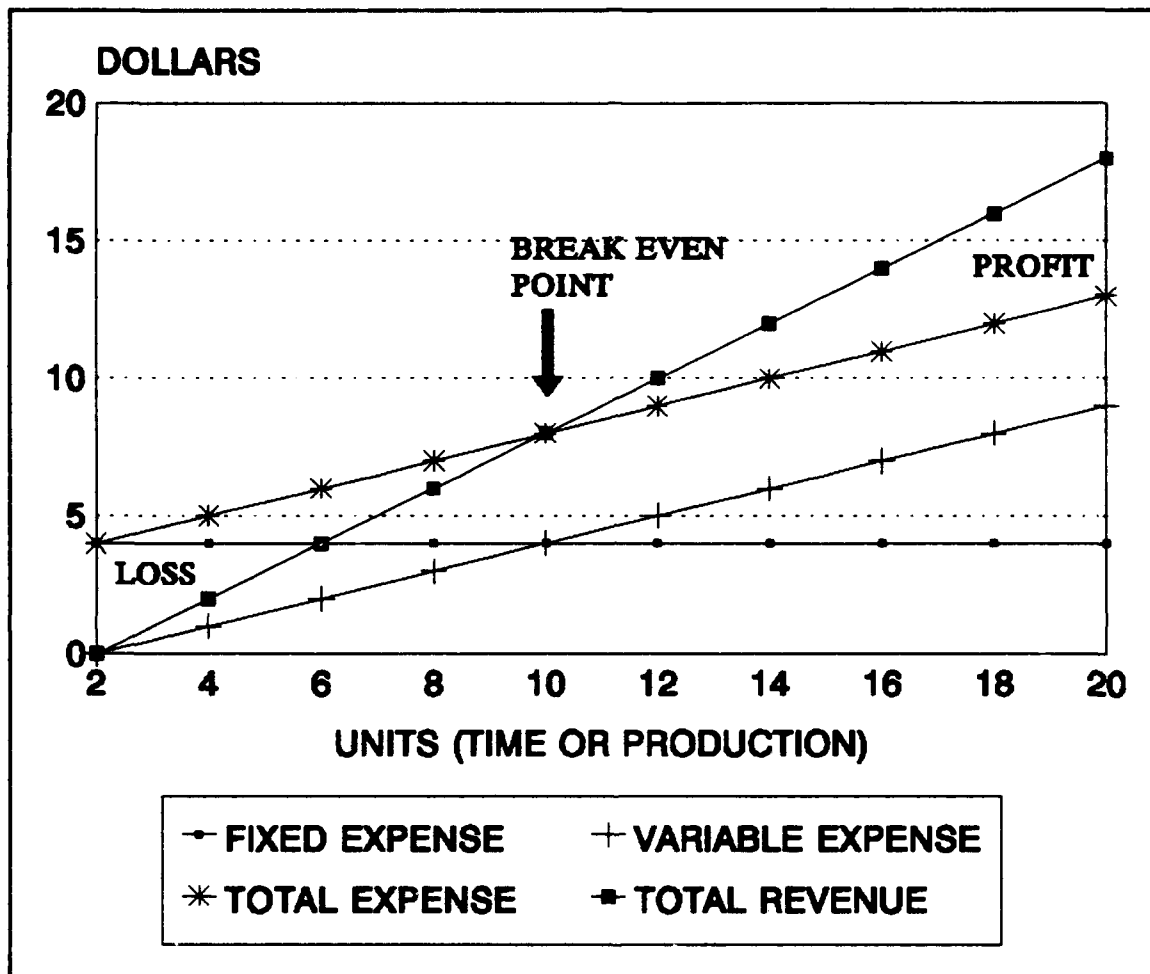
Figure 7-1 Graphic of Break Even Analysis

The break even chart depicts graphically the following:

1. The fixed expenses line. This line is unaffected by production volume or output and is parallel to the units axis.

2. The variable expense line. Variable costs are directly dependent on the increase in units. They increase as do revenues, but hopefully at a slower rate. Common examples of variable costs are labor, fuel and production materials.

3. Cumulative revenue. This is the third line and it represents the total revenue generated by the sale of "X" units of the product.

The intersection of total plus variable costs and revenues represents the break even point. Additional production and sales to the right of the break even point result in profits. Sales and production to the left of the break even point cause the revenue to fall below costs and represent a loss.

Competing alternatives can be examined graphically using the format of Figure 7-1. When examining alternatives, revenue and costs are evaluated separately. Walker (1991) says that because revenue is a dependent variable of cost, it is not particularly useful in this form of capital budget consideration. Assuming competing alternatives produce the same output, cost avoidance is a primary concern over the economic life of a proposal. Therefore, an alternative which has the lower costs should also have the highest potential for profitability. In considering alternatives, it is critical to find the break even point at which both alternatives are considered equal. Break Even Analysis is particularly useful to evaluate the individual characteristics of variable components (time, cost, output) and to quantify the relationship between them.

An example considers two different commercial telephone carriers offering service for your business. Each carrier has a fixed monthly charge for service and an addtional charge per call. Given the following data find the break even point for the two alternatives.

Solution:

$$TC = FC + VC_x$$

(Where TOTAL COST is (TC), FIXED COST is (FC), VARIABLE COST is (VC) at some level (x).)

Each figure is expressed in Equation 7-1 (a) and (b):

$$TC_A=25.00+0.025(X) \qquad \text{Equation 7-1(a)}$$

$$TC_B=32.50+0.010(X) \qquad \text{Equation 7-1(b)}$$

The relationship can be solved algebraically using the general cost equation as displayed in Equation 7-2:

$$TC_A=TC_B$$

$$=25.00+0.025(X)=32.50+0.010(X) \qquad \text{Equation 7-2}$$

$$0.15(X)=7.50$$

$$X=\frac{7.50}{0.015}=500 calls$$

Figure 7-2 graphically portrays the break even analysis. The horizontal axis is the number of phone calls per month. The vertical axis represents the cumulative cost for these calls. The graph displays the cost for each telephone service

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carrier.   The break even point is 500 telephone calls where
both services have exactly the same total cost.
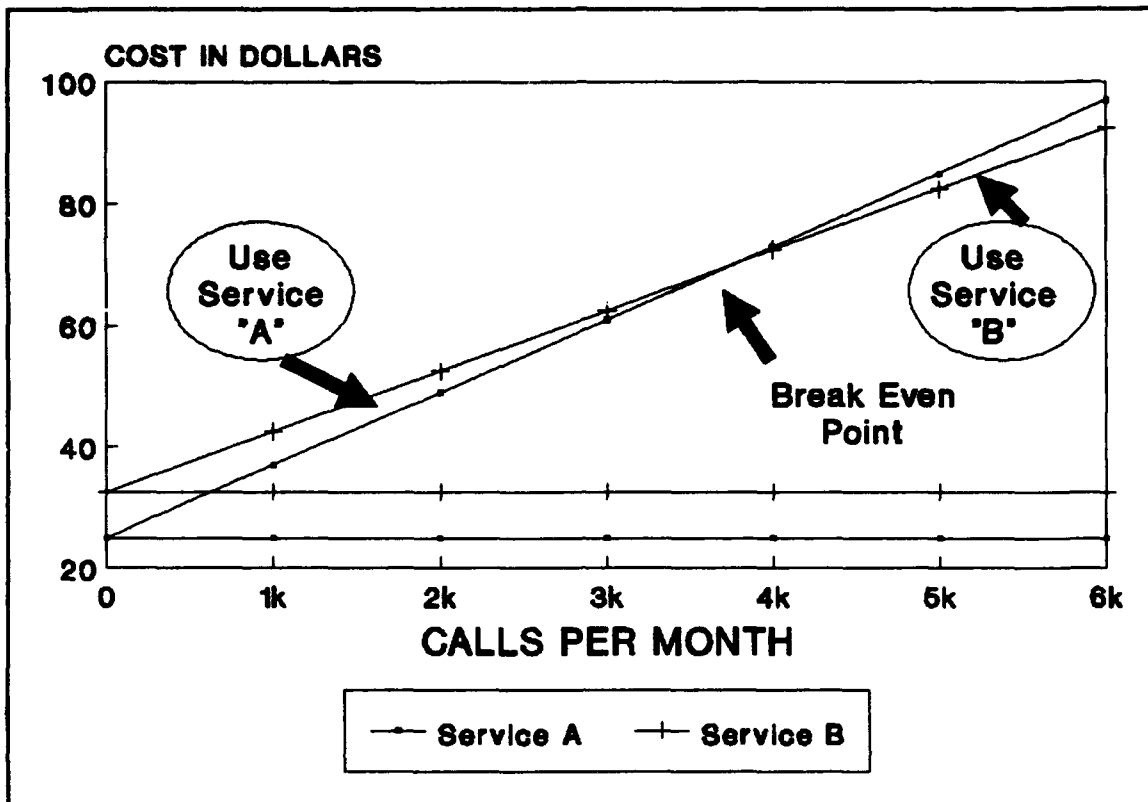
Figure 7-2   Break Even Analysis Example 1

Notice that the least cost alternative is based on the
volume of telephone calls.   If less than 500 calls are made
monthly, Service A is the least cost alternative. Conversely,
Service B would be preferred if more than 500 phone calls are
made monthly.

Often alternatives may have different economic lives or
may use different funding strategies.   In cases where cash
flow or economic periods are different, costs must be adjusted
using the present value technique.   Using the previous
example, both telephone services offer a contract system.

Under the terms of contract services both carriers provide station extensions at a reduced rate. Company A provides its service for an annual flat fee of $2,500.00 and a cost of $0.012 per call. Company B offers a commercial switch board for $4,500 and a monthly flat fee of $167 per month for a leased line. If both contracts are for 5 years, find the break even point of the two alternatives.

Figure 7-3 contains the solution for the cash flow of the two systems.

ALTERNATIVE A

YEAR	0	1	2	3	4	5
FIXED COSTS	2500	2500	2500	2500	2500	2500
VARIABLE COSTS	.012X	.012X	.012X	.012X	.012X	.012X
DISCOUNT FACTOR	1	.954	.868	.789	.717	.652

Expressed as: (2500 + 0.012x)*4.98 =12,445 +0.059x

ALTERNATIVE B

YEAR	0	1	2	3	4	5
FIXED COSTS	2000	2000	2000	2000	2000	2000
INVESTMENT COST	4500					
DISCOUNT FACTOR	1	.954	.868	.789	.717	.652

Expressed as: 4500 + (2000 * 4.98) =14,456

Figure 7-3 Cash Flow for Alternatives A & B

The present values for the alternatives are shown in Figure 7-4

According to the terms of the proposals, if the office averages 23 calls per day (assuming 250 working days annually) both options would result in the same cost over the economic

$$PV_a = 12,445 + 0.059X \qquad PV_b = 14,456$$

TO FIND THE BREAK EVEN POINT SOLVE FOR x.

$$PV_a = PV_b$$
$$12,445 + 0.059x = 14,456$$
$$0.059x = 2011$$
$$x = 34,084 \text{ calls} = 6,817 \text{ calls per year for 5 years}$$

Figure 7-4 Present Value Analysis of Alternatives A & B

life of the alternative. If you make less than 6,817 phone calls per year, Alternative A is preferred. If you make more than 6,817 phone calls, Alternative B would more economical.

C. SUMMARY

The discounted break even analysis is a useful decision making tool when considering alternatives which have fixed and variable costs. The method provides accurate results for alternatives with different funding strategies. Incorporating the present value technique into break even analysis makes the output sensitive to the time value of money. While the method is not capable of dealing with non-monetary costs and benefits, it converts product output, productivity and time into quantifiable monetary units.

VIII. INTERNAL RATE OF RETURN

A. BACKGROUND

The internal rate of return (or time adjusted rate of return) is described by Parker and Benson (1988) as the interest yield projected on an investment over its economic life. Garrison (1991) says the internal rate of return is the cumulative discount rate that will cause a project's net present value to equal zero. Haga and Lang (1992) compute internal rate of return in two separate steps. First a proposal's initial investment is divided by the annual cost savings, the result is called the time adjusted factor. This is compared to the present value of an annuity of $1 in arrears. A copy of the present value annuity table is provided in Appendix B. The percentage rate that corresponds to the time adjusted factor is the Internal Rate of Return (IRR). This technique is appropriate when the investment has constant savings over time.

B. CALCULATION OF INTERNAL RATE OF RETURN

A maintenance activity is considering purchasing a Seal Packaging (Sealpak) machine. The machine is designed to encase maintenance components, installing diagrams, and miscellaneous assembly pieces in a heavy plastic vacuum sealed wrap. The Sealpak will reduce lost assembly pieces and

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contamination of sensitive components by salt water or dirt. The machine costs $16,950.00. It has an economic life of 10 years and will save $3,000.00 per year.

To compute the internal rate of return associated with the Sealpak, use the following formula:

$$F_{ta} = \frac{PV_i}{S_a} = \frac{\$16,950}{\$3,000} = 5.650 \qquad \text{Equation 8-1}$$

(Where F_{ta} = Time Adjusted Factor, PV_i = Present Value of Investment, and S_a Annual Savings.)

With F_{ta} computed go to the Present Value in Arrears Table (Appendix B). Go to the row representing 10 years, the economic life of Sealpak. Read across the row to find the value of F_{ta}, 5.650. This value is found in the 12% interest column. The 12% interest rate represents the internal rate of return for this example.

IRR is used in the capital budgeting process to determine if a proposal exceeds minimum accepted rates of return on investments. Levy and Sarnat (1982) noted that when the IRR is used to analyze two competing alternatives, the alternative with the highest IRR is preferred.

Garrison (1991) points out that this analysis tool is extremely useful if a project's cash flows are constant. However, it is not particularly adaptable to irregular cash flows. Investments with irregular annual cost savings require using trial and error to calculate the proposal's IRR. These calculations can prove time consuming and tedious. It is

therefore more appropriate to use economic analysis techniques previously discussed when confronted with irregular cash flows.

C. HURDLE RATE

The IRR can be used as a method to screen out undesirable investments. IRR uses a concept commonly referred to as a hurdle rate. This screening tool is a predetermined minimum rate of return a proposal must clear to be considered. By using the hurdle rate, decision makers are able to devote more attention to business opportunities which meet established minimum criteria. The hurdle rate is demonstrated in the following example.

Two proposals are being considered. Alternative 1 is a wireless infrared network to be used with operations planning groups. Because of the dynamics of users, this will significantly reduce rewiring requiremens and system down time. Cost of alternative 1 is $25,000. The annual cost savings $5,800. The economic life is 10 years.

Alternative 2 is a backup air conditioner for the main frame Automated Services Center. The system costs $60,000. It has an economic life of 15 years and has an estimated cost savings of $9,000.00.

Management has set the hurdle rate at 14% for all capital budget proposals. Determine if these proposals meet the hurdle rate criteria.

	ALTERNATIVE 1	ALTERNATIVE 2
INITIAL INVESTMENT	$25,000	$60,000
ANNUAL SAVINGS	$5,800	$9,000
ECONOMIC LIFE	10 years	15 years
F_a	4.31	6.67
IRR	18.7%	12.2%
HURDLE RATE	14%	14%
Above Hurdle Rate	4.7%	<1.8%>

Figure 8-1 Hurdle Rate Analysis

In the example, Alternative 1 would be approved because it exceeds the hurdle rate of 14%. This option would the be further examined using other economic analysis tools to determine its acceptability. Alternative 2 would be rejected because it failed to satisfy the hurdle rate.

While the hurdle rate is an acceptable methodology for screening economic proposals, it should not be used in conjunction with an investment capital ceiling. Establishing a capital ceiling would prevent decisions being focused on a low investment/high return short term investment strategy.

D. SUMMARY

The IRR is an efficient economic analysis tool. It provides a concise representation of the investment/savings ratio of business proposals. The methodology is expressed as a projected annual yield, an excellent measure with which to base business decisions. Despite these attributes, the IRR does have several limitations.

IRR is difficult to calculate when considering irregular cash flows. This may require a trial-and-error processes. In these instances, other analysis tools permit a more robust examination of capital investment opportunities.

IRR also does not calculate outcomes in dollar values. Because the analysis is expressed in rates of return, high profit ventures may be looked over because of high initial investments, despite projected long range returns.

IX. BENEFIT COST RATIO

A. BACKGROUND

Information technology can be viewed as another stage in the long evolutionalry process of acquiring new means to overcome man's unaided capabilities. Straussman (1985) said that acquiring this technological support depends on relationship between benefits and costs. Quirin and Wiginton (1981) define benefits as cash inflows which result from either monetary or non-monetary business improvements. Monetary benefits are derived from cost savings, cost avoidance, or generation of revenues. Non-monetary benefits result from improved efficiency, reduced delivery time, or increases in productivity.

Parker and Benson (1988) state that the benefit cost ratio is an extremely useful tool in evaluating non-monetary benefits to determine the potential of capital investments. The Benefit Cost Ratio (BCR) is calculated by dividing an alternative's benefits by its uniform annual cost. The result is the benefit received per each unit of cost for an alternative. Walker says that because an alternative's uniform annual cost is in the calculation, the benefit cost ratio considers the time value of money and can evaluate alternatives with differing economic lives. Garrison says

that because the BCR analysis technique calculates a ratio of benefits to costs, the alternative with the highest result is preferred.

B. QUANTIFIABLE BENEFITS

For benfits that are quantifiable, Haga and Lang (1992) express BCR in the following notation.

$$BCR = \frac{QOM}{UAC}$$ Equation 9-1

(Where QOM is a Quantifiable Output Measure, and UAC is Uniform Annual Cost.)

By using the BCR technique, alternatives can be rated based on the contribution of non-monetary benefits. The following examples, adapted from Haga and Lang (1992), illustrate how this analysis is preformed.

Two processes are being considered to handle administrative review. The current process is manual. It is slow and tedious, permitting only 39,000 annual reviews. An automated system is being considered. It would double the output, accommodating 78,000 reviews per year. The status quo system costs $206,250 per year. The automated system has an initial purchase cost of $2,175,000 and has recurring costs of $256,250 per year for the last eight of its nine year economic life.

To perform the analysis you would need to compute the BCR for each alternative. Figure 9-1 summarizes each of the benefits and costs.

	STATUS QUO SYSTEM	AUTOMATION SYSTEM
ECONOMIC LIFE	9 YEARS	9 YEARS
INITIAL COST	0	2,175,000
ANNUAL OP COST	206,250	256,250
OUTPUT/YEAR	37,000	78,000

Figure 9-1 Summary of Benefits and Costs

Because this alternative involves non-monetary, quantifiable benefits, the investment BCR analysis is appropriate assuming the value of an annual review is constant regardless of the total number of annual reviews completed. The first step in solving this example is to identify the non-monetary benefits. Output varies from 37,000 annual records in the status quo system to 78,000 in the automation alternative. The next step is to determine the annual cost per alternative. Using the formulas contained in Chapter V the UAC is determined to be

$$UAC_{statusquo} \frac{(206,250)*9*(6.741)}{6.741} = 1,856,250 \qquad \text{Example 9-1(a)}$$

$$UAC_{alt1} 2,175k*(0.967) + \frac{256k*8*(6.741-.967)}{6.741} = 2,068k \qquad \text{Ex 9-1(b)}$$

58

Now that the UAC of each alternative has been calculated it is applied as the denominator to equation 9-1.

$$BCR_{statusquo} = \frac{37,000}{1,856,250} = 0.019$$

$$BCR_{alt1} = \frac{78,000}{2,067,931} = 0.038$$

The BCR analysis of each alternative reveals that Alternative 2, the proposed automation, is economically preferred. Alternative 2 has a higher BCR which represents a greater benefit per individual unit of cost for the proposed system. It is important to note that the solution appears to contradict results of the UAC technique. This is not the case. As Walker (1991) points out, the fundamental difference between BCR and UAC is the assumption under Uniform Annual Cost analysis that benefits for each alternative are equal. The difference in benefits is the over riding constraint used to evaluate Benefit Cost Ratio Analysis.

C. NON-QUANTIFIABLE BENEFITS

Parker and Benson (1988) point out that benefits considered in an analysis are frequently qualitative and difficult to measure. These qualitative factors often significantly influence other factors or measurable costs. Examples of these factors could be availability, timeliness, data accuracy, quality, or ease of use. Haga and Lang (1992)

offered the Aggregate Benefit Value (ABV) to measure these non-quantifiable benefits.

The ABV is performed once all applicable non-quantative benefits are identified. Each of these benefits must be converted to a quantitative form. This is done by performing a short three step process.

1. Rank benefits of a project from 1-3 according to their relative importance. The number 3 has the greatest relative importance. The number 1 has the least relative importance.

2. Prioritize or rank each benefit with respect to desirability. Rank these factors between 1-10. The number 10 has the greatest appeal and the number 1 the least.

3. Multiply the results corresponding to steps 1 and 2 for each factor. The factors for all non-qualitative factors are then summed.

Summing these weighted values gives the ABV. This factor then becomes the numerator in Equation 9-1, replacing Quantifiable Output Measure.

Figure 9-2 demonstrates the ABV process for a manual and automated process. In particular, suppose the previous output values of 37,000 for the manual system and 78,000 for the automated system are unknown or are not the primary benefits. If the remaining data is unchanged determine the BCR.

The solution to example 9-2 would use the ABV's contained in Figure 9-2.

Alternative 1 (Manual) ABV = 131

Alternative 2 (Automated) ABV = 134

BENEFITS MANUAL

	FACTOR WEIGHT	RANKING	PRODUCT
DATA AVAILABILITY	3	9	27
DATA TIMLINESS	3	9	27
DATA ACCURACY	3	10	30
ERGONOMICS	2	5	10
DECISION SUPPORT	2	5	10
PORTABILITY	2	9	18
ABV			131

BENEFITS AUTOMATED

	FACTOR WEIGHT	RANKING	PRODUCT
DATA AVAILABILITY	3	8	24
DATA TIMLINESS	3	7	21
DATA ACCURACY	3	8	24
ERGONOMICS	2	10	20
DECISION SUPPORT	2	9	18
PORTABILITY	3	9	27
ABV			134

FIGURE 9-2   Solution to Example 9-2

After the ABV for each alternative is calculated the result becomes the numerator for equation 9-1. The UAC for each alternative becomes the denominator.

$$BCR_{statusquo} = \frac{131}{1.8M} = 72.77$$

$$BCR_{alt1} = \frac{134}{2M} = 67$$

In this example Alternative 1, the Status Quo system, is preferred. This may appear confusing given the different results from essentially the same data. It is essential to

understand that the quality of BCR is directly related to the data used in the analysis. Turbin (1990) observes that the more subjective the benefits the softer or suspect the values. By their nature, subjective measures place substantial demands upon the analyst's knowledge about the organization's goals. They also require unbiased understanding of each alternative's capabilities.

D. SUMMARY

Benefit Cost Ratio is designed to determine the benefits received relative to an alternative's cost per unit. Unlike previously discussed economic analysis tools, BCR can evaluate non-monetary benefits and can accommodate both structured and non-structured profitability. Because it uses UAC, BCR is sensitive to the time value of money. BCR can also be used to measure unstructured or unknown benefits by using the Aggregate Benefit Value (ABV). When used properly, BCR can examine the relationship between competing proposal's costs and non-quantifiable benefits.

X. FUNCTIONAL ECONOMIC ANALYSIS

A. BACKGROUND

The Functional Economic Analysis Development Action Plan (FEA/DAP) (1992) says that Function Economic Analysis (FEA) is a management tool to support and document the costs and benefits of business process improvements and related investments in information technology. The FEA Guidebook (1992) adds that this is a evolving process intended to meet the unique demands of computer technology. FEA is the primary means of presenting and defending the IT budget, acquisition, and functional planning process. The FEA/DAP (1992) states that FEA is now providing CIM functional linkages in both the POM 94/95 and FY 1994 budget submission for all IT items.

B. FUNCTIONAL ECONOMIC ANALYSIS DEFINED

A FEA is the primary document in the decision package evaluating actions to achieve a functional objective. This includes selecting migration systems, implementation, and justifying data and information changes. FEA is used to:

- evaluate proposed courses of action
- present the business case for approving and implementing the proposed action, and

- evaluate the business case at appropriate decision points for program continuation or re-direction (LCM milestones, or program changes).

FEA is a complete and on-going analysis of alternatives over the life cycle of IT investments. It was developed to support functional decision making and support analysis of cost incurred and benefits realized in IT investments.

C. FEA PREPARATION

The first step in the FEA process is the Functional Process Improvement (FPI) cycle. FPI is a six step process in which management collects, process and evaluates data relevant to the IT alternative. The six steps include: define, analyze, evaluate, plan, approve, and execute. Each step will be discussed in turn.

1. Define

Definition describes the current status of the proposal. This description is expressed in terms of costs, processes, performance measures, inventories, and other attributes. These inputs form the framework for preparing the program's scope and objectives. From this strategies are devised to achieve the desired objective in relation to the Baseline state. Straussman (1991) refers to baselines, objectives and strategies as the project's "Functional Direction."

2. Analyze

Once the functional base is developed, the current process is analyzed in an effort to identify potential improvements. In this process, the FEA Guidebook (1992) states that Activity Based Costing (ABC) or Unit Costing techniques are employed. These methods provide a structured approach to documenting current processes and improvements. The process improvement step also uses Total Quality Management (TQM) techniques to assess obstacles, survey relevant practices and analyze data sources and information flows.

3. Evaluate

The Evaluation Phase models potential improvements to determine how the proposal should be implemented. During this step individual proposals are packaged as alternatives. Each alternative describes a possible plan for attaining an objective. This step considers costs in manpower, resources, and materials over time required by each alternative. This evaluation is expressed in monetary terms to determine the most efficient outlay with regard to costs and benefits.

4. Plan, Approve, and Execute

Plan, Approve, and Execute represent the last three steps of the FPI cycle in Figure 10-1. These three steps are on-going once an alternative is selected. Each step provides the FEA with information and feedback as to how the selected

alternative is performing in relative to the plan. During

these steps:

- Detailed planning is conducted to augment the defined strategy

- Any deviation from the plan, objectives, or strategies is agreed upon and approved and the evaluation is updated to determine the revised costs, and

- Once the plan is approved, it is executed. As additional information is acquired, it is used in an iterative process, providing source data for continual improvement for the concept and design.
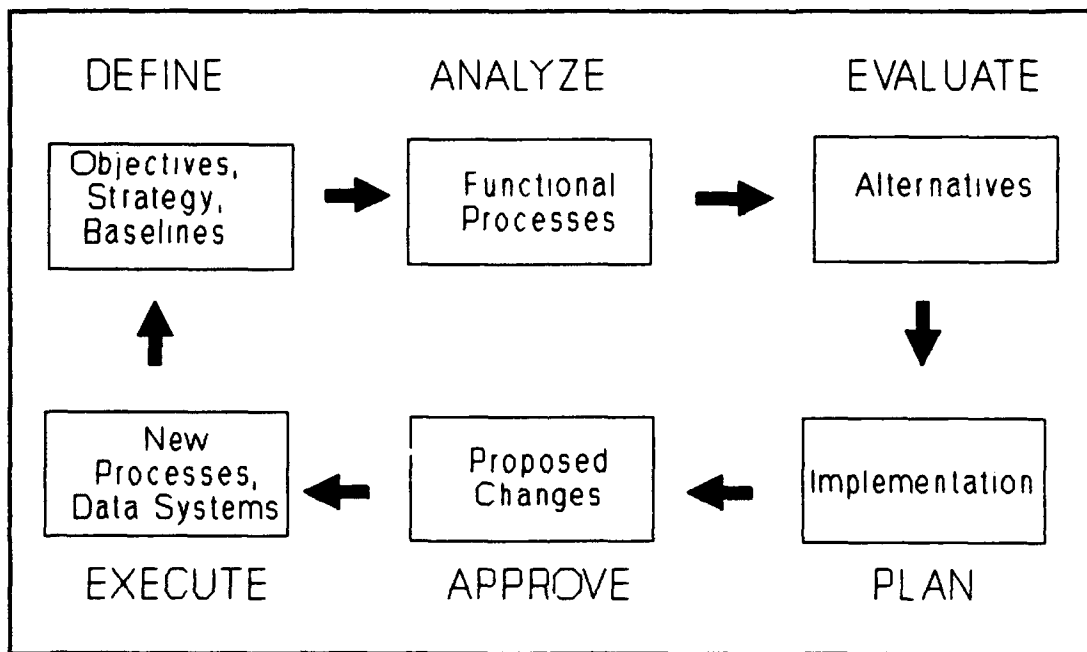
Figure 10-1 Functional Process Improvement Cycle

D. FEA PRINCIPLES

FEA methodology, according to the FEA Guidebook (1992), is directed by three general principles. These principles guide management activities at the functional activity level.

1. Functional Focus

FEA is designed to evaluate changes in a functional process. FEA provides decision makers with a bottom line approach to use resources effectively in meeting defined objectives and strategies. This focus is intended to measure costs and benefits associated with IT investments and insure that these refinements constitute function improvement or value added capability.

2. Measurement

FEA requires that key elements are weighted, including the costs and output of a functional process. Quantitative measures are essential to decision makers in determining an alternative's economic feasibility.

3. On-Going Management Tool

FEA is an on-going requirement. This methodology refines and updates information on a continual basis. Details pertinent to the tasking and functional areas of concern are reviewed as shown in Figure 10-1.

E. FUNCTIONAL ECONOMIC ANALYSIS MODEL

The Functional Economic Analysis Model (FEAM) is an evolving economic analysis tool for evaluating requirements of

the FEA process. FEAM is being developed by the Institute for Defense Analysis and is available for DoD Service members and employees.

FEAM was designed to support the FEA process in two manners:

- FEAM aids in the analysis of potential cost savings and
- FEAM simplifies data analysis during the FPI cycle and Business Case process.

FEAM serves an intermediary mode. Its objective is to receive data and process information regarding competing alternatives. The model then compares this information to the budget Baseline. The Baseline, according to the FEA Guidebook (1992), is a point of reference for measuring progress in process improvement and relative cost analysis. FEAM presents the simulation results in graphical and tabular format.

1. System Requirements

FEAM is designed to operate on either an IBM^{TM} compatible or Apple Macintosh^{TM} machine. FEAM is an add on application written as a macro for MicroSoft Excel^{TM}. Because FEAM operates in the MicroSoft Windows^{TM} and Multifinder^{TM} environments, it has the benefit of Graphic User Interface (GUI) and What-You-See-Is-What-You-Get (WYSIWYG) terminal emulation. In addition to the software requirements, FEAM has the following hardware criteria:

- A mouse

- 2MB of RAM

- 20MB of Hard Disk space

- EGA display

The following upgrades are recommended to enhance system responsiveness:

- 4MB of RAM or higher

- Math co-processor

- VGA monitor or higher

2. FEAM Menu Overview

FEAM's menu structure is divided into four levels.

a. Level 1

Level 1 is the program's initial menu options and screen display. There are ten options, divided into three different categories:

(1) Program Functions

Program Functions include file, view, print, and Help options generic to Windows™ and Multifinder™ application environments.

(2) Simulation Parameters

Simulation Parameters are definition settings and execution options used to designate the FEA Risk Adjusted Discounted Cash Flow procedures. The discount rate and number of model simulations are selected in this option.

(3) *Program or Alternative Definition*

Program or Alternative Definition are used to enter data elements which describe the Baseline, Current Base, and Each Alternative. This menu option also serves as the path to the three lower levels.

b. Level 2

Level 2 has two purposes, graphics display and access to lower levels of the data entry tables. The graphs displayed in this level show the cost breakout between Operations and Management and Support.

c. Level 3

Level 3 provides the cost element breakouts represented over time. These displays reveal the cost element spending over the life cycle of each alternative.

d. Level 4

Level 4 is the alternative cost input data fields.

3. Data Analysis

Once a proposal is entered into FEAM, the model evaluates the data using the Risk Adjusted Discounted Cash Flow (RADCF) method. The data values are entered into a model simulator and its resulting values are displayed in tables and graphics.

RADCF calculations simulate the probable best and worse case scenario to establish upper and lower bounds for

the relative success of each proposal. Using this information FEAM conducts a Monte Carlo simulation, by cost element, for each alternative. Options selected from within Level 1 will determine whether an intermediate (100 simulations) or a final (500 iterations) simulation is calculated. The simulations form the most probable program path. This is compared against the Baseline to determine the potential savings for each alternative.

The model simulation routine is quite sophisticated and calculation intensive. Average simulation times for the Baseline machine (an IBM compatable 80386 SX 16MHz system with 2MB RAM) was 45 minutes for an intermediate analysis.

F. SUMMARY

Functional Economic Analysis provides an integral part of the CIM strategy to facilitate process improvement into DoD IT programs and budgeting. This methodology analyzes an investment's potential benefit and standardizes the information necessary to perform the process. It is an evolving process developed to meet DoD's growing needs and the changing technological base.

When FEAM is used to perform the RADCF simulation, detailed economic analysis can be performed by non-economists in a intermediary mode to support the Business Case methodology. However, FEAM is currently limited only to FEA related applications.

XI. PC ECONPACK

A. BACKGROUND

Turbin (1990) says a decision support system (DSS) is an interactive flexible and adaptable computer based information system that uses decision rules, models, and model base. Coupled with the decision maker's own insights, this leads to specific implementable decisions in solving problems that are not ameanable to management science optimization. By design, a DSS supports complex decision making and increases an organization's effectiveness by providing a structured process for making these decisions.

The Personal Computer version of Economic Analysis Package (ECONPACK) is a unique economic analysis tool that supports functional economic analysis. ECONPACK is available to personnel throughout the Department of Defense and provides a comprehensive computer based decision support system which incorporates economic analysis, calculations, documentation, and reporting capabilities. Developed by the U.S. Army Corps of Engineers, this data analysis application is structured so that it can be used by non-economists to prepare complete, properly documented economic analysis in support of Department of Defense funding requests. ECONPACK is a menu driven

program featuring interactive display screens enabling the user to select and specify functions. The programs has generic analytic capabilities that provide standardized economic analysis methodologies to a broad range of capital investment categories.

Two versions of the Automatic Economic Analysis Package are available. The first is the PC version requiring a 80286 IBM compatible computer operating DOS version 3.2 or higher. The second is the Mainframe application which can be accessed via the Programming, Administration, and Execution (PAX) computer system. Both the PC and Mainframe versions provide the capability to transmit data packets to/from other systems employing ECONPACK. This was designed into the system to allow analysts to develop Economic Analysis off line, then transmit files as part of a multi year appropriation funding request.

ECONPACK is used to develop Economic Analysis in support of multi-year appropriations, including but not limited to, military housing construction, procurement, research and development, test and evaluation, and military leasing. This computer based information system performs standardized life cycle cost calculations, including net present value, equivalent uniform annual cost, savings to investment ratio, and discounted payback period. It also provides graphical output for cost sensitivity analysis and discounted rate payback analysis.

B.   CAPABILITIES OF ECONPACK.

ECONPACK provides support for decision makers in semi-structured and unstructured situations bringing together human judgement and computerized information. Support provided for top executives is focused on their strategic planning needs. Support is provided to individuals as well as groups by either the PAX system or through the PC ECONPACK data transmission. The graphics output of ECONPACK supports less structured problems which frequently involve individuals from different departments and organizational levels. ECONPACK can assist in the decision making process.

ECONPACK provides support to all phases of the decision making process: intelligence, design, choice, and implementation. It uses a comprehensive seven step process. The steps include:

1. Establish and state the objective

2. Identify alternatives

3. Form assumptions

4. Determine costs and Benefits

5. Compare the alternatives

6. Perform the Sensitivity Analysis

7. Generate Results, Recommendations & Review Output.

Each of these steps is automated within the system and steps are performed sequentially to ensure both a thorough economic analysis and traceable documentation for each proposal.

ECONPACK supports a variety of decision making situations. It is flexible so users can add, delete, combine, or rearrange basic elements over time. This capability permits ad hoc analysis. ECONPACK improves decision making effectiveness (accuracy, timeliness, and quality). It is not as concerned with decision making efficiency (cost of making the decision, including computer time).

The major capability of ECONPACK is its ability to create models from scratch or from existing data. The system allows users to manipulate data so that different scenarios can be developed. ECONPACK possesses the ability to store and manage a wide variety of different types of models and to access and integrate model data. It also permits model tracking, to manage and maintain the model base

The file maintenance facility in ECONPACK catalogues all the files in the model base. It includes the data set for each model and the graphical output associated with each analysis. Each model is maintained in a free form text. Thus, the analysis can be reviewed without reassimilation.

The help menus are identified on all screens of ECONPACK. Bennett (1977) said that this component of a DSS is the single most important characteristic associated with design.

Interface is divided into three components:

- action language
- display

- and knowledge base

The Action Language is how a user communicates with the system. Input options are specified from the computer keyboard and function keys. Mouse support and Windows compatibility are not offered. Display relates to on-screen graphics. ECONPACK's display is uncluttered with accessable help commands and menu options. Knowledge base, according to Bennett (1977), refers to the information that a user must possess to use the whole system. This may be the weak point of the system. ECONPACK is generally used in the intermediary mode. This means that non-economists prepare the analysis for decision makers, and are often unaware of the specific capabilities or limitations of a analysis technique. They may not be able to identify the most appropriate technique for the data set available.

C. ECONPACK TESTING METHODOLOGY

A verification and validation of ECONPACK was conducted using the problems developed in preceding chapters. The scope of these tests was to verify ECONPACK results against manually computed solutions. This form of test is called "black box" or functionality analysis. According to Andriole (1986), "black box" testing is designed external, or independent of the software. No consideration is given to the internal logic, control or data flow in developing the data set. Given

a known quantity, the software should produce an acceptable if not exact result.

The problems discussed in each of the previous chapters were used as test data. The problem definitions represent the relative domain of each technique evaluation. Break-Even analysis, Internal Rate of Return, and Benefit Cost Ratio were not tested as they are currently unsupported by ECONPACK.

1. Net Present Value

This ECONPACK module was tested using both examples presented in discussing the NPV technique. ECONPACK Summary and Project Cost Reports are contained in Appendix D. During the black box tests, the following areas deviated from the values computed manually.

- period of analysis
- computation of the discount factor for the current year.

Each example's economic life was entered into ECONPACK's General Information subsection of the Data Entry and Modification module. ECONPACK interpreted the economic life of these problems as periods of analysis. The data definition caused recurring difficulty in document entry. Example 1 possessed an economic life of five years, which was calculated based on the fiscal year of acquisition and each of the five years of operation. ECONPACK does not have the capability to evaluate current year investments as part of the

problem set. To overcome this situation, a period of analysis of six years (initial investment, plus five out years) was entered. Once this adjustment was made in the baseline example, a fit of .9705 was achieved by declaring the following values;

- period of analysis 6 years
- program start year 1993
- base year 1994

Each example's period of analysis was redefined for each methodology and remained constant throughout the rest of the functionality testing.

ECONPACK had a 0.0295 error in calculating the NPV for current year investments. This error rate occurs when calculating the discount factor. As discussed in Chapter II, the formula for computing the middle of the year discount factor was presented in Equation 2-5

$$MOY = \frac{1}{(1+i)^{(n-.5)}}$$ Equation 2-5

(n the year of analysis, and i equals interest rate)
when $n \geq 1$. However, if $n = 0$ then the following formula, contained in Example 11-1, applies:

$$MOY = \frac{1}{(1+i)^0} = 1$$ Example 11-1

However with these constraints ECONPACK computes the discount
factor for the base or current year (n=0) as shown in Equation
11-1:

$$MOY_{ECONPACK} = \frac{1}{(1+i)^{(0-.5)}} = 1.049 \qquad \text{Equation 11-1}$$

The middle of the year discount factor computed in this manner
inflates values for the current year. Figure 11-1 shows the
control NPV calculations compared to ECONPACK's (from Appendix
C).

```
                         NPV Example 1

          Benchmark Calculation

n                   0      1      2      3      4      5
Discount Factor     1    .954   .867   .788   .717   .652
COST            20,000  3,000  3,000  3,000  3,000  3,000
PV COST         20,000  2,862  2,601  2,364  2,151  1,956
TOTAL NPV:                                          31,934

          ECONPACK Calculation

n                   0      1      2      3      4      5
Discount Factor 1.049   .953   .867   .788   .716   .651
COST            20,000  3,000  3,000  3,000  3,000  3,000
PV COST         20,976  2,860  2,600  2,364  2,149  1,954
TOTAL NPV:                                          32,904
```

Figure 11-1   Comparision of Benchmark to ECONPACK NPV
Calculations.

ECONPACK computes all discount factors in a similar
manner when the start year (n=0) is less than the base year.
This condition is pervasive in each discounting convention.
Because the discount factor is a common component in each of

ECONPACK's techniques, all results are affected by this abnormality.

2. Uniform Annual Cost

The unique characteristic of the UAC technique is its ability to evaluate alternatives with different economic lives. In the current configuration, ECONPACK does not support this capability.

In UAC Example 1, two alternatives were described. Attributes of these alternatives are provided in the Figure 11-2.

BENCHMARK CALCULATIONS

ALTERNATIVE A
NPV_A = 325k+(35k*3.739)+(45k*.717)+(40k*.652)+(60k*.489) = $543,550
UAC_A = $543,550 ÷ 5.597 = $97,114

ALTERNATIVE B
NPV_B = 350k+(25k*3.326)+(50k*.652) = $465,750
UAC_B = $465,750 ÷ 3.978 = $117,081

ECONPACK CALCULATIONS

ALTERNATIVE A
NPV_A = (325k*1.049)+(35k*3.739)+(45k*.717)+(40k*.652)+(60k*.489) =
$559,475
UAC_A = $559,475 ÷ 5.597 = $99,960

ALTERNATIVE B
NPV_B = (350k*1.049)+(25k*3.326)+(50k*.652) = $482,900
UAC_B = $482,900 ÷ 3.978 = $121,393

Figure 11-2 Comparision of Benchmark to ECONPACK UAC Calculations

ECONPACK requires identifying the analysis period during the program definition. The economic life is entered once on the

General Information Screen. Because this field permits only one period of analysis, ECONPACK uses the cumulative discount factor corresponding to the longer period of analysis. This situation resulted in the least cost alternative being incorrectly identified in both UAC examples. ECONPACK gives a correct answer if UAC is used only when economic alternatives are reoccurring. By calculating the least common multiplier, the cost data can be repeated to determine equivalent economic replacement costs. In Example 1, the least common multiplier is 40 years. However, the least common multiplier approach is not always convenient, practical, or supported. Example 2 has a least common multiplier of 120 years, an unsupported analysis period.

3. Savings Investment Ratio

Savings Investment Ratio is used to rank capital budget proposals based on their potential cost savings. ECONPACK only considers proposals that are evaluated against the status quo. Evaluating competing investment projects for budget decisions and calculating the hurdle rate threshold are not analytical options.

The data fit between manual and ECONPACK SIR solutions, shown in Figure 11-3, was .9655. The deviation of .0345 results from discount factor errors previously discussed.

```
Benchmark

  Savings     $500k + (50k * 6.447) = $822k
  Investment  $704k - (20k * 0.405) = $696k
  SIR_Benchmark = 709+696=1.18

Econpack

  Savings     ($500k *1.049) + (50k * 6.447) = $846k
  Investment  ($704k * 1.049) - (20k * 0.405) = $730k
  SIR_Econpack = 846+730=1.16
```

Figure 11-3   Comparison of Benchmark to ECONPACK SIR Calculations

4. Discounted Payback Period

Discounted payback analysis evaluates the period of time necessary for an investment to recoup its own initial costs. The resulting analysis is expressed as the number of years required for payback. ECONPACK calculations, shown in Figure 11-4, are consistent with manual solutions and achieved a data fit of 0.995. However, the current DPA configuration is restricted to data that meet the pre-conditions associated with SIR. DPA is automatically calculated with SIR calculations. As with the SIR analysis, evaluating competing investment projects for budget decisions or calculating the hurdle rate threshold are not available options.

```
Benchmark

    PV_i - PV_t = 2280 - (250 * 0.652) = 2117

          PV_s = 750 * 3.977 = 2983

    (PV_i - PV_t) + S = 2117 + 750 = 2.823 ~ 3.3 years

                    DPP _Benchmark = 3.3 Years

Econpack

    PV_i - PV_t = (2280 * 1.049) - (250 * 0.652) = 2391

          PV_s = 750 * 3.975 = 2981

    (PV_i - PV_t) + S = 2391 + 750 = 3.188 ~ 3.5 years

                    DPP _Econpack =  3.5 Years
```

Figure 11-4   Comparison of Benchmark to ECONPACK DPA Calculations.

D. SUMMARY

ECONPACK is a useful DSS tool to support functional economic analysis. It is designed as an intermediary DSS tool that is intended to simplify FEA requirements for capital investment analysis by non-economists. ECONPACK is limited to supporting the following analysis methods:

- Net Present Value

- Uniform Annual Cost

- Savings Investment Ratio

- Discounted Payback Analysis

Functionality testing of ECONPACK detected deviations from the expected values developed in analysis technique discussions. These deviations were attributed to:

- data definition of period for analysis
- calculation of discount factors
- handling of alternatives with different economic lives

Evaluating criteria was restricted in calculating the savings opportunity for competing investment proposals and establishing rate hurdles for capital budgeting decisions.

XII. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

Recent changes in the threat to U.S. defenses have caused a significant shift in national priority. Executive and Legislative focus has moved from the demands of the Cold War to deficit reduction and economic reform. The corresponding reductions in DoD funding will translate to tighter control of resources. This effort should represent a significant challenge to DoD throughout the decade. The delicate balance between capabilities and resources will necessitate thorough review of capital investments for IT programs or systems.

A thoughtful yet efficient review methodology was developed by Corporate Information Management (CIM) for this purpose. The process, entitled FEA, is an integral component of DoD process improvement and evaluates the value of IT programs by measuring benefits in relation to costs. FEA represents an evolving methodology which will use different economic analysis techniques to support the evaluation process.

The analysis techniques presented in this thesis account for the time value of money over the life cycle of an investment. Additionally each economic analysis tool offers

unique properties for evaluating capital investment alternativies.

1. **Net Present Value** evaluates competing alternatives with equal economic lives, and benefits.

2. **Uniform Annual Cost** is useful in examining alternatives with differing economic lives.

3. **Savings Investment Ratio** evaluates the relationship between investment and projected return.

4. **Benefit Cost Ratio** is used to quantify non-monetary benefits and evaluate them respective of their initial investment.

5. **Discounted Payback Analysis** expresses the relationship between costs and benefits in the time necessary to recoup the investment.

6. **Breakeven Analysis** looks at output in units while evaluating variable costs.

7. **Internal Rate of Return** expresses output as a percent of return on investment.

CIM is developing the FEAM as a computer based analysis tool. These computer based tools help standardize and enhance the management review process. In addition to supporting the decision process, DSS increases the capability for decision makers to identify costs over a proposed lifecycle with repsect to value. In supporting program life cycle development, FEAM uses the business case methodolog. FEAM was designed to support analysis of potential cost savings proposals for IT managment, in order to meet force reduction levels presented in the DMR. FEAM is a MicroSoft Excel™ application operating in the Windows™ environment.

PC Econpack is a DOS based program designed by the USACE to support capital investment decisions. PC Econpack has automated the economic analysis process, by operating in the intermediary mode permitting non-economists to provide evaluation support.

PC Econpack and FEAM provide users with convenient computer based economics tools. These programs permit decision makers to prepare timely and consistant analysis of data. ECONPACK and FEAM are available for use by DoD activities. Appendix D provides addresses to obtain software and supporting documentation.

B. Recommendations

Each technique discussed has a unique purpose in supporting FEA. Software applications used to consider capital investments for information technology should provide a broad computing capability to thoroughly evaluate these decisions. The following recommendations are provided:

1. Econpack

ECONPACK's capabilities be expanded to include the eight analysis techniques discussed.

Discrepancies observed in investment handling and calculating current year discount factors be corrected.

Expand ECONPACK's UAC module, to evaluate alternative's with different economic lives.

ECONPACK should be included as a module within FEAM to handle capital investment analysis.

2. FEAM

Expand the analysis capabilities in FEAM to include each capital investment tool discussed in this paper. These techniques contribute to the complete analysis of IT investment options and expand the functionality to the end user level.

APPENDIX A

A. 7% Discount Table

Year	Discount Factor	Cumulative Discount Factor
1	0.967	0.967
2	0.904	1.871
3	0.844	2.716
4	0.737	3.454
5	0.737	4.192
6	0.689	4.881
7	0.644	5.526
8	0.602	6.128
9	0.563	6.691
10	0.526	7.217
11	0.491	7.709
12	0.459	8.169
13	0.429	8.598
14	0.401	8.999
15	0.375	9.375
16	0.350	9.725
17	0.327	10.053
18	0.306	10.359
19	0.286	10.645
20	0.267	10.913
21	0.250	11.163
22	0.233	11.396
23	0.218	11.615
24	0.204	11.819
25	0.190	12.009
26	0.178	12.188
27	0.166	12.354
28	0.155	12.510
29	0.145	12.655
30	0.136	12.791

B. 10% Discount Table

Year	Discount Factor	Cumulative Discount Factor
1	0.954	0.954
2	0.867	1.821
3	0.788	2.609
4	0.717	3.326
5	0.652	3.978
6	0.592	4.570
7	0.538	5.108
8	0.489	5.597
9	0.445	6.042
10	0.404	6.446
11	0.368	6.814
12	0.334	7.148
13	0.304	7.452
14	0.276	7.728
15	0.251	7.979
16	0.228	8.207
17	0.207	8.414
18	0.188	8.602
19	0.171	8.773
20	0.156	8.929
21	0.141	9.070
22	0.129	9.119
23	0.117	9.316
24	0.106	9.422
25	0.096	9.518
26	0.088	9.606
27	0.080	9.686
28	0.072	9.758
29	0.066	9.824
30	0.060	9.884

APPENDIX B

A. PRESENT VALUE OF AN ANNUITY OF $1 IN ARREARS

	4%	5%	6%	8%	10%	12%	14%
1	0.962	0.952	0.943	0.926	0.909	0.893	0.877
2	1.886	1.859	1.833	1.783	1.736	1.690	1.647
3	2.775	2.723	2.673	2.577	2.487	2.402	2.322
4	3.630	3.546	3.465	3.312	3.170	3.037	2.914
5	4.452	4.329	4.212	3.993	3.791	3.605	3.433
6	5.242	5.076	4.917	4.623	4.355	4.111	3.889
7	6.002	5.786	5.582	5.206	4.868	4.564	4.288
8	6.733	6.463	6.210	5.747	5.335	4.968	4.639
9	7.435	7.108	6.802	6.247	5.759	5.328	4.946
10	8.111	7.722	7.360	6.710	6.145	5.650	5.216
11	8.760	8.306	7.887	7.139	6.495	5.938	5.453
12	9.385	8.863	8.384	7.536	6.814	6.194	5.660
13	9.986	9.394	8.853	7.904	7.103	6.424	5.842
14	10.563	9.899	9.295	8.244	7.367	6.628	6.002
15	11.118	10.380	9.712	8.559	7.606	6.811	6.142
16	11.652	10.838	10.106	8.851	7.824	6.974	6.265
17	12.166	11.274	10.477	9.122	8.022	7.120	6.373
18	12.659	11.690	10.828	9.372	8.201	7.250	6.467
19	13.134	12.085	11.158	9.604	8.365	7.366	6.550
20	13.590	12.462	11.470	9.818	8.514	7.469	6.623

	16%	18%	20%	22%	24%	26%	28%	30%
1	0.862	0.847	0.833	0.820	0.806	0.794	0.781	0.769
2	1.605	1.566	1.528	1.492	1.457	1.424	1.392	1.361
3	2.246	2.174	2.106	2.042	1.981	1.923	1.868	1.816
4	2.798	2.690	2.589	2.494	2.404	2.320	2.241	2.166
5	3.274	3.127	2.991	2.864	2.745	2.635	2.532	2.436
6	3.685	3.498	3.326	3.167	3.020	2.885	2.759	2.643
7	4.039	3.812	3.605	3.416	3.242	3.083	2.937	2.802
8	4.344	4.078	3.837	3.619	3.421	3.241	3.076	2.925
9	4.607	4.303	4.031	3.786	3.566	3.366	3.184	3.019
10	4.833	4.494	4.192	3.923	3.682	3.465	3.269	3.092
11	5.029	4.656	4.327	4.035	3.776	3.543	3.335	3.147
12	5.197	4.793	4.439	4.127	3.851	3.606	3.387	3.190
13	5.342	4.910	4.533	4.203	3.912	3.656	3.427	3.223
14	5.468	5.008	4.611	4.265	3.962	3.695	3.459	3.249
15	5.575	5.092	4.675	4.315	4.001	3.726	3.483	3.268
16	5.668	5.162	4.730	4.357	4.033	3.751	3.503	3.283
17	5.749	5.222	4.775	4.391	4.059	3.771	3.518	3.295
18	5.818	5.273	4.812	4.419	4.080	3.786	3.529	3.304
19	5.877	5.316	4.843	4.442	4.097	3.799	3.539	3.311
20	5.929	5.353	4.870	4.460	4.110	3.808	3.546	3.316

APPENDIX C: Econpack Output

A. Net Present Value

EXECUTIVE SUMMARY REPORT   PAGE 001

PROJECT TITLE   : EXAMPLE 2 CHAPTER 3 (NET PRESENT VALUE)
DISCOUNT RATE   : 10.00%
PERIOD OF ANALYSIS: 6 YEARS
START YEAR   : 1993
BASE YEAR   : 1994

PROJECT OBJECTIVE :

RESULTS AND RECOMMENDATIONS:

ALTERNATIVE NAME	NPV	EUAC	SIR	DPP
1 ALTERNATIVE 3	$30,340	$7,630		
2 ALTERNATIVE 4	$25,898	$6,513	0.00	

ACTION OFFICER:
ORGANIZATION :

PROJECT/PROGRAM COSTS

ALTERNATIVE 1: ALTERNATIVE 3

ALTERNATIVE 3 YEAR (01)	TOTAL ANNUAL OUTLAYS	MIDDLE OF YEAR DISCOUNT FACTORS	PRESENT VALUE	CUMULATIVE NET PRESENT VALUE
1993	$7,000	$7,000	1.049	$7,342	$7,342
1994	$3,000	$3,000	0.953	$2,860	$10,202
1995	$3,000	$3,000	0.867	$2,600	$12,802
1996	$3,000	$3,000	0.788	$2,364	$15,166
1997	$3,000	$3,000	0.716	$2,149	$17,315
1998	$20,000	$20,000	0.651	$13,025	$30,340

%NPV   100.00
         $30,340
DISCOUNTING
CONVENTION   M-O-Y

EQUIVALENT UNIFORM ANNUAL COST = $7,630 (10.00% DISCOUNT RATE, 6 YEARS)

PROJECT/PROGRAM COSTS

ALTERNATIVE 2: ALTERNATIVE 4

ALTERNATIVE 4 YEAR (01)	TOTAL ANNUAL OUTLAYS	MIDDLE OF YEAR DISCOUNT FACTORS	PRESENT VALUE	CUMULATIVE NET PRESENT VALUE
1993	$6,000	$6,000	1.049	$6,293	$6,293
1994	$1,000	$1,000	0.953	$953	$7,246
1995	$1,000	$1,000	0.867	$867	$8,113
1996	$1,000	$1,000	0.788	$788	$8,901
1997	$1,000	$1,000	0.716	$716	$9,617
1998	$25,000	$25,000	0.651	$16,281	$25,898

%NPV   100.00
          $25,898
DISCOUNTING
CONVENTION   M-O-Y

EQUIVALENT UNIFORM ANNUAL COST = $6,513 (10.00% DISCOUNT RATE, 6 YEARS)

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PRIMARY ECONOMIC ANALYSIS

Present Alternative: ALTERNATIVE 3
Proposed Alternative: ALTERNATIVE 4

Project Year(s)	Recurring Annual Operating Costs		Differential Cost	Present Value Factor	Present Value of Differential Cost
	Present Alternative	Proposed Alternative			
1993	$7,000	$6,000	$1,000	1.049	$1,049
1994	$3,000	$1,000	$2,000	0.953	$1,907
1995	$3,000	$1,000	$2,000	0.867	$1,733
1996	$3,000	$1,000	$2,000	0.788	$1,576
1997	$3,000	$1,000	$2,000	0.716	$1,433
1998	$20,000	$25,000	-$5,000	0.651	-$3,256
Totals	$39,000	$35,000	$4,000		$4,442

Total present value of investment	$0
Plus: present value of existing assets to be used	$0
Less: present value of existing assets replaced	$0
Less: present value of terminal value of alternative	$0
Total present value of net investment	$0
Total present value of differential costs	$4,442
Plus: present value of cost of refurbishment or modification eliminated	$0
Less: status quo salvage value	$0
Total present value of savings	$4,442

Savings/Investment ratio   No investment data
SIR is less than one at end of period of analysis

For Status Quo

Recurring Costs - Expense Item(s) 1

For Proposed Alternative

Recurring Costs - Expense Item(s) 1

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0016: PRIMARY ANALYSIS
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0026: 1*0
0027: DISCOUNT FACTORS ARE &
0028: 1*2
0029: RECURRING COSTS ARE &
0030: 1
0031: END ALTERNATIVE  1
0032: *
0033: BEGIN ALTERNATIVE  2
0034: ALTERNATIVE NAME IS &
0035: 'ALTERNATIVE 4'
0036: EXPENSE ITEM  1 IS 'ALTERNATIVE:4: ' &
0037: 1*6000 4*1000 1*25000
0038: INFLATION FACTORS ARE &
0039: 1*0
0040: DISCOUNT FACTORS ARE &
0041: 1*2
0042: RECURRING COSTS ARE &
0043: 1
0044: END ALTERNATIVE  2
0045: *
0046: STOP RUN

** END OF RUN **
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B. Uniform Annual Cost Example

EXECUTIVE SUMMARY REPORT   PAGE 001

PROJECT TITLE   : EXAMPLE 1 CHAPTER 4 (UNIFORM ANNUAL COST)
DISCOUNT RATE   : 10.00%
PERIOD OF ANALYSIS: 9 YEARS
START YEAR   : 1993
BASE YEAR   : 1994

PROJECT OBJECTIVE :

RESULTS AND RECOMMENDATIONS:

ALTERNATIVE NAME	NPV	EUAC	SIR	DPP
1 ALTERNATIVE A	$559,350	$99,966		
2 ALTERNATIVE B	$482,760	$86,278	0.00	

ACTION OFFICER: MAJOR R. M. POWELL
ORGANIZATION :

PROJECT/PROGRAM COSTS

ALTERNATIVE 1: ALTERNATIVE A

ALTERNATIVE A YEAR (01)	TOTAL ANNUAL OUTLAYS	MIDDLE OF YEAR DISCOUNT FACTORS	PRESENT VALUE	CUMULATIVE NET PRESENT VALUE
1993	$325,000	$325,000	1.049	$340,863	$340,863
1994	$35,000	$35,000	0.953	$33,371	$374,234
1995	$35,000	$35,000	0.867	$30,337	$404,571
1996	?35,000	$35,000	0.788	$27,579	$432,150
1997	$45,000	$45,000	0.716	$32,236	$464,386
1998	$40,000	$40,000	0.651	$26,049	$490,435
1999	$35,000	$35,000	0.592	$20,721	$511,156
2000	$35,000	$35,000	0.538	$18,837	$529,993
2001	$60,000	$60,000	0.489	$29,357	$559,350

%NPV   100.00
          $559,350
DISCOUNTING
CONVENTION   M-O-Y

EQUIVALENT UNIFORM ANNUAL COST = $99,966 (10.00% DISCOUNT RATE, 9 YEARS)

99

PROJECT/PROGRAM COSTS

ALTERNATIVE 2: ALTERNATIVE B

ALTERNATIVE B YEAR (01)	TOTAL ANNUAL OUTLAYS	MIDDLE OF YEAR DISCOUNT FACTORS	PRESENT VALUE	CUMULATIVE NET PRESENT VALUE
1993	$350,000	$350,000	1.049	$367,083	$367,083
1994	$25,000	$25,000	0.953	$23,837	$390,920
1995	$25,000	$25,000	0.867	$21,670	$412,590
1996	$25,000	$25,000	0.788	$19,700	$432,290
1997	$25,000	$25,000	0.716	$17,909	$450,199
1998	$50,000	$50,000	0.651	$32,561	$482,760
1999	$0	$0	0.592	$0	$482,760
2000	$0	$0	0.538	$0	$482,760
2001	$0	$0	0.489	$0	$482,760

%NPV   100.00
      $482,760
DISCOUNTING
CONVENTION M-O-Y

EQUIVALENT UNIFORM ANNUAL COST = $86,278 (10.00% DISCOUNT RATE, 9 YEARS)

PRIMARY ECONOMIC ANALYSIS

Present Alternative: ALTERNATIVE A
Proposed Alternative: ALTERNATIVE B

Project Year(s)	Recurring Annual Operating Costs Present Alternative	Proposed Alternative	Differential Cost	Present Value Factor	Present Value of Differential Cost
1993	$325,000	$350,000	-$25,000	1.049	-$26,220
1994	$35,000	$25,000	$10,000	0.953	$9,534
1995	$35,000	$25,000	$10,000	0.867	$8,667
1996	$35,000	$25,000	$10,000	0.788	$7,879
1997	$45,000	$25,000	$20,000	0.716	$14,327
1998	$40,000	$50,000	-$10,000	0.651	-$6,512
1999	$35,000	$0	$35,000	0.592	$20,721
2000	$35,000	$0	$35,000	0.538	$18,837
2001	$60,000	$0	$60,000	0.489	$29,357
Totals	$645,000	$500,000	$145,000		$76,590

Total present value of investment	$0
Plus: present value of existing assets to be used	$0
Less: present value of existing assets replaced	$0
Less: present value of terminal value of alternative	$0
Total present value of net investment	$0
Total present value of differential costs	$76,590
Plus: present value of cost of refurbishment or modification eliminated	$0
Less: status quo salvage value	$0
Total present value of savings	$76,590

Savings/Investment ratio   No investment data
SIR is less than one at end of period of analysis

For Status Quo

Recurring Costs - Expense Item(s) 1

For Proposed Alternative

Recurring Costs - Expense Item(s) 1

101

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0026: 1*0
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0028: 1*2
0029: RECURRING COSTS ARE &
0030: 1
0031: END ALTERNATIVE  1
0032: *
0033: BEGIN ALTERNATIVE  2
0034: ALTERNATIVE NAME IS &
0035: 'ALTERNATIVE B'
0036: EXPENSE ITEM  1 IS 'ALTERNATIVE:B: ' &
0037: 1*350000 4*25000 1*50000 3*0
0038: INFLATION FACTORS ARE &
0039: 1*0
0040: DISCOUNT FACTORS ARE &
0041: 1*2
0042: RECURRING COSTS ARE &
0043: 1
0044: END ALTERNATIVE  2
0045: *
0046: STOP RUN

** END OF RUN **
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C. Savings Investment Ratio Example

EXECUTIVE SUMMARY REPORT   PAGE 001

PROJECT TITLE   : Example 1 Chapter 5 (Saving Investment Ratio)
DISCOUNT RATE   : 10.00%
PERIOD OF ANALYSIS: 11 YEARS
START YEAR   : 1993
BASE YEAR   : 1994

PROJECT OBJECTIVE :

RESULTS AND RECOMMENDATIONS ($ in thousands):

ALTERNATIVE NAME	NPV	EUAC	SIR	DPP
1 Unsecure Network	$846	$130		
2 upgrade	$730	$112	1.16	6.2 YEARS

ACTION OFFICER: R. M. Powell
ORGANIZATION : Naval Postgraduate School

PROJECT/PROGRAM COSTS ($ in thousands)

ALTERNATIVE 1: Unsecure Network

YEAR	Unsecure Magazine Network (01)	TOTAL ANNUAL OUTLAYS	MIDDLE OF YEAR DISCOUNT FACTORS	PRESENT VALUE	CUMULATIVE NET PRESENT VALUE
1993	$500	$500	1.049	$524	$524
1994	$50	$50	0.953	$48	$572
1995	$50	$50	0.867	$43	$615
1996	$50	$50	0.788	$39	$654
1997	$50	$50	0.716	$36	$690
1998	$50	$50	0.651	$33	$723
1999	$50	$50	0.592	$30	$753
2000	$50	$50	0.538	$27	$780
2001	$50	$50	0.489	$24	$804
2002	$50	$50	0.445	$22	$826
2003	$50	$50	0.404	$20	$846

%NPV   100.00
         $846
DISCOUNTING
CONVENTION   M-O-Y

EQUIVALENT UNIFORM ANNUAL COST = $130 (10.00% DISCOUNT RATE, 11 YEARS)

PROJECT/PROGRAM COSTS ($ in thousands)

ALTERNATIVE 2: upgrade

YEAR	UPGRADE (01)	TOTAL ANNUAL OUTLAYS	MIDDLE OF YEAR DISCOUNT FACTORS	PRESENT VALUE	CUMULATIVE PRESENT VALUE
1993	$704	$704	1.049	$738	$738
1994	$0	$0	0.953	$0	$738
1995	$0	$0	0.867	$0	$738
1996	$0	$0	0.788	$0	$738
1997	$0	$0	0.716	$0	$738
1998	$0	$0	0.651	$0	$738
1999	$0	$0	0.592	$0	$738
2000	$0	$0	0.538	$0	$738
2001	$0	$0	0.489	$0	$738
2002	$0	$0	0.445	$0	$738
2003	$0	$0	0.404	$0	$738

%NPV   101.10
          $738
DISCOUNTING
CONVENTION   M-O-Y

YEAR	PRESENT VALUE RESIDUAL	CUMULATIVE NET PRESENT VALUE
1993	$0	$738
1994	$0	$738
1995	$0	$738
1996	$0	$738
1997	$0	$738
1998	$0	$738
1999	$0	$738
2000	$0	$738
2001	$0	$738
2002	$0	$738
2003	$8	$730

%NPV   -1.10
          $8
DISCOUNTING
CONVENTION   E-O-Y

PROJECT/PROGRAM COSTS ($ in thousands)

ALTERNATIVE 2: upgrade

EQUIVALENT UNIFORM ANNUAL COST = $112 (10.00% DISCOUNT RATE, 11 YEARS)

PRIMARY ECONOMIC ANALYSIS ($ in thousands)

Present Alternative: Unsecure Network
Proposed Alternative: upgrade

Project Year(s)	Recurring Annual Operating Costs Present Alternative	Proposed Alternative	Differential Cost	Present Value Factor	Present Value of Differential Cost
1993	$500	$0	$500	1.049	$524
1994	$50	$0	$50	0.953	$48
1995	$50	$0	$50	0.867	$43
1996	$50	$0	$50	0.788	$39
1997	$50	$0	$50	0.716	$36
1998	$50	$0	$50	0.651	$33
1999	$50	$0	$50	0.592	$30
2000	$50	$0	$50	0.538	$27
2001	$50	$0	$50	0.489	$24
2002	$50	$0	$50	0.445	$22
2003	$50	$0	$50	0.404	$20
Totals	$1,000	$0	$1,000		$846

Total present value of investment	$738
Plus: present value of existing assets to be used	$0
Less: present value of existing assets replaced	$0
Less: present value of terminal value of alternative	$8
Total present value of net investment	$730
Total present value of differential costs	$846
Plus: present value of cost of refurbishment or modification eliminated	$0
Less: status quo salvage value	$0
Total present value of savings	$846
Savings/Investment ratio	1.16
Discounted Payback Period	6.2 years

For Status Quo

Recurring Costs - Expense Item(s) 1

For Proposed Alternative

Investment Costs - Expense Item(s) 1

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0012: START YEAR IS 1993
0013: BASE YEAR IS 1994
0014: DISCOUNT RATE IS 10.00
0015: GLOBAL DISCOUNTING CONVENTION IS 2
0016: PRIMARY ANALYSIS
0017: COST STORED IN 'THOUSANDS OF' DOLLARS
0018: END DATA
0019: *
0020: BEGIN ALTERNATIVE 1
0021: ALTERNATIVE NAME IS &
0022: 'Unsecure Network'
0023: EXPENSE ITEM  1 IS 'Unsecure:Magazine:Network' &
0024: 1*500 10*50
0025: INFLATION FACTORS ARE &
0026: 1*0
0027: DISCOUNT FACTORS ARE &
0028: 1*2
0029: RECURRING COSTS ARE &
0030: 1
0031: END ALTERNATIVE 1
0032: *
0033: BEGIN ALTERNATIVE 2
0034: ALTERNATIVE NAME IS &
0035: 'upgrade'
0036: EXPENSE ITEM  1 IS 'UPGRADE: : ' &
0037: 1*704 10*0
0038: INFLATION FACTORS ARE &
0039: 1*0
0040: DISCOUNT FACTORS ARE &
0041: 1*2
0042: SALVAGE VALUE IS 20
0043: RESIDUAL INFLATION INDEX IS  0
0044: RESIDUAL DISCOUNTING CONVENTION IS 3
0045: INVESTMENT COSTS ARE &
0046: 1
0047: END ALTERNATIVE 2
0048: *
0049: STOP RUN

** END OF RUN **
```

D. Discounted Payback Period Analysis

EXECUTIVE SUMMARY REPORT   PAGE 001

PROJECT TITLE   : Discounted (Payback Period Analysis
DISCOUNT RATE   : 10.00%
PERIOD OF ANALYSIS: 6 YEARS
START YEAR   : 1993
BASE YEAR   : 1994

PROJECT OBJECTIVE :

RESULTS AND RECOMMENDATIONS:

ALTERNATIVE NAME	NPV	EUAC	SIR	DPP
1 Current System	$2,981	$749		
2 alternative 1	$2,228	$559	1.34	4.5 YEARS

ACTION OFFICER: R. M. Powell
ORGANIZATION : NPS

LIFE CYCLE COST REPORT   PAGE 001

PROJECT/PROGRAM COSTS

ALTERNATIVE 1: Current System

current syst em YEAR (01)	TOTAL ANNUAL	MIDDLE OF YEAR OUTLAYS FACTORS	PRESENT DISCOUNT	CUMULATIVE NET PRESENT VALUE	VALUE
1993	$0	$0	1.049	$0	$0
1994	$750	$750	0.953	$715	$715
1995	$750	$750	0.867	$650	$1,365
1996	$750	$750	0.788	$591	$1,956
1997	$750	$750	0.716	$537	$2,493
1998	$750	$750	0.651	$488	$2,981

%NPV   100.00
    $2,981
DISCOUNTING
CONVENTION   M-O-Y

EQUIVALENT UNIFORM ANNUAL COST = $749 (10.00% DISCOUNT RATE, 6 YEARS)

LIFE CYCLE COST REPORT   PAGE 002

PROJECT/PROGRAM COSTS

ALTERNATIVE 2: alternative 1

alternative 1 YEAR (01)	TOTAL ANNUAL	MIDDLE OF YEAR OUTLAYS FACTORS	PRESENT DISCOUNT	CUMULATIVE PRESENT VALUE	VALUE

109

1993	$2,280	$2,280	1.049	$2,391	$2,391
1994	$0	$0	0.953	$0	$2,391
1995	$0	$0	0.867	$0	$2,391
1996	$0	$0	0.788	$0	$2,391
1997	$0	$0	0.716	$0	$2,391
1998	$0	$0	0.651	$0	$2,391

%NPV   107.32
       $2,391
DISCOUNTING
CONVENTION   M-O-Y

YEAR	PRESENT VALUE RESIDUAL	CUMULATIVE NET PRESENT VALUE
1993	$0	$2,391
1994	$0	$2,391
1995	$0	$2,391
1996	$0	$2,391
1997	$0	$2,391
1998	$163	$2,228

%NPV   -7.32
       $163
DISCOUNTING
CONVENTION   M-O-Y

EQUIVALENT UNIFORM ANNUAL COST = $559 (10.00% DISCOUNT RATE, 6 YEARS)

PRIMARY ECONOMIC ANALYSIS

Present Alternative: Current System
Proposed Alternative: alternative 1

Project Year(s)	Recurring Annual Operating Costs		Differential Cost	Present Value Factor	Present Value of Differential Cost
	Present Alternative	Proposed Alternative			
1993	$0	$0	$0	1.049	$0
1994	$750	$0	$750	0.953	$715
1995	$750	$0	$750	0.867	$650
1996	$750	$0	$750	0.788	$591
1997	$750	$0	$750	0.716	$537
1998	$750	$0	$750	0.651	$488
Totals	$3,750	$0	$3,750		$2,981

Total present value of investment	$2,391
Plus: present value of existing assets to be used	$0
Less: present value of existing assets replaced	$0
Less: present value of terminal value of alternative	$163
Total present value of net investment	$2,228
Total present value of differential costs	$2,981
Plus: present value of cost of refurbishment or modification eliminated	$0
Less: status quo salvage value	$0
Total present value of savings	$2,981
Savings/Investment ratio	1.34
Discounted Payback Period	4.5 years

For Status Quo

Recurring Costs - Expense Item(s) 1

For Proposed Alternative

Investment Costs - Expense Item(s) 1

```
0001: * VERSION 3.0
0002: PROJECT TITLE IS 'Discounted (Payback Period Analysis'
0003: ACTION OFFICER IS 'R. M. Powell'
0004: ORGANIZATION IS 'NPS'
0005: OBJECTIVE IS &
0006: ' '&
0007: ' '&
0008: ' '
0009: *
0010: BEGIN DATA
0011: PERIOD OF ANALYSIS IS  6 YEARS
0012: START YEAR IS 1993
0013: BASE YEAR IS 1994
0014: DISCOUNT RATE IS 10.00
0015: GLOBAL DISCOUNTING CONVENTION IS 2
0016: PRIMARY ANALYSIS
0017: COST STORED IN 'ACTUAL' DOLLARS
0018: END DATA
0019: *
0020: BEGIN ALTERNATIVE  1
0021: ALTERNATIVE NAME IS &
0022: 'Current System'
0023: EXPENSE ITEM  1 IS 'current system: ' &
0024: 1*0 5*750
0025: INFLATION FACTORS ARE &
0026: 1*0
0027: DISCOUNT FACTORS ARE &
0028: 1*2
0029: RECURRING COSTS ARE &
0030: 1
0031: END ALTERNATIVE  1
0032: *
0033: BEGIN ALTERNATIVE  2
0034: ALTERNATIVE NAME IS &
0035: 'alternative 1'
0036: EXPENSE ITEM  1 IS 'alternative:1: ' &
0037: 1*2280 5*0
0038: INFLATION FACTORS ARE &
0039: 1*0
0040: DISCOUNT FACTORS ARE &
0041: 1*2
0042: SALVAGE VALUE IS 250
0043: RESIDUAL INFLATION INDEX IS  0
0044: RESIDUAL DISCOUNTING CONVENTION IS 2
0045: INVESTMENT COSTS ARE &
0046: 1
0047: END ALTERNATIVE  2
0048: *
0049: STOP RUN
** END OF RUN **
```

APPENDIX D

SOFTWARE INFORMATION

To receive a copy of ECONPACK contact:

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> **P.O. BOX 1600**
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> **HUNTSVILLE,AL 35807-4301**
>
> **POC: Mr. Bob Morgan**
> **COMM: (205) 955-5266**
> **DSN: 645-5266**

To receive a copy of FEAM contact:

> **INSTITUTE FOR DEFENSE ANALYSES**
> **1801 N. BEAUREGARD ST.**
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